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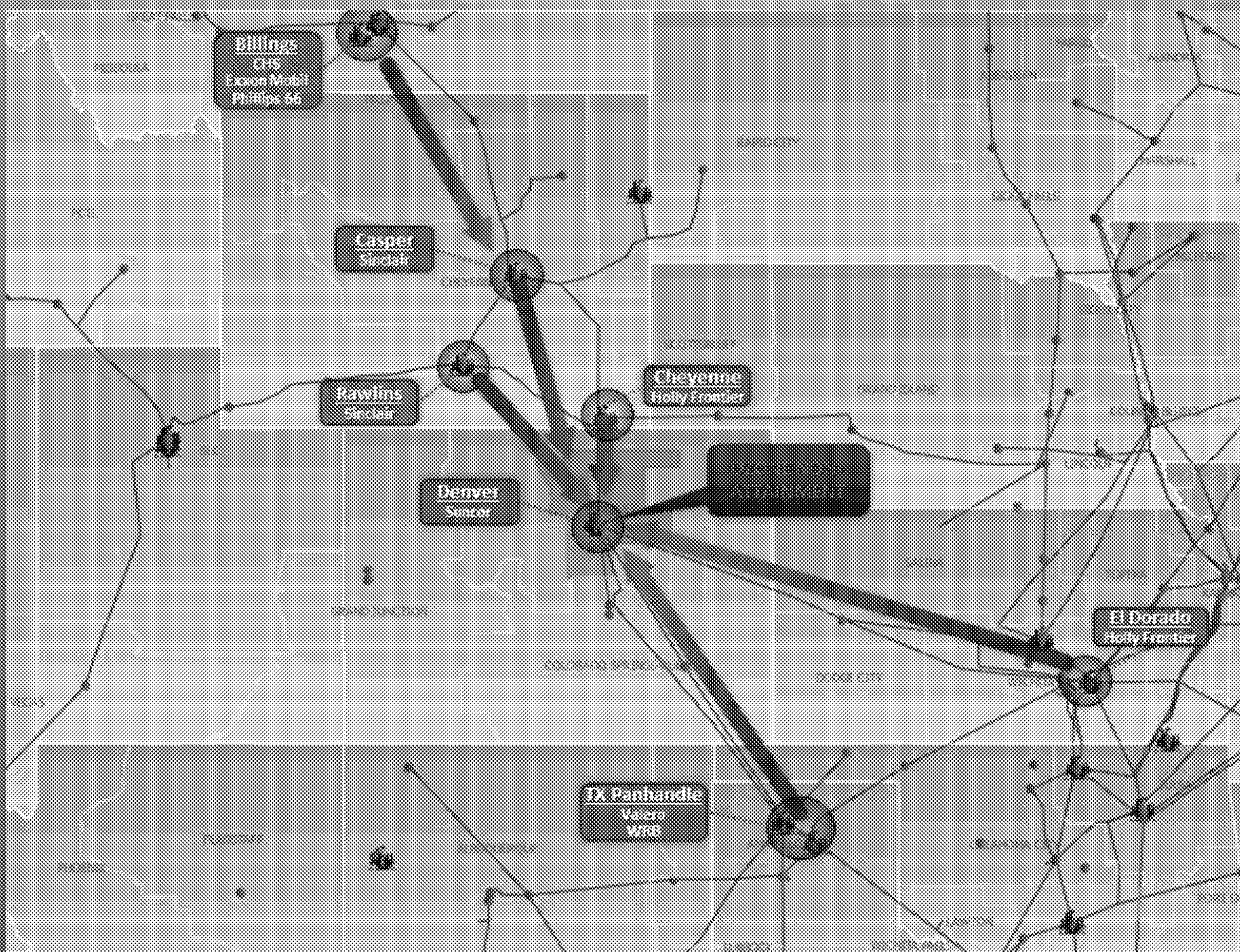

DENVER METRO/NORTH FRONT RANGE FUEL SUPPLY IMPACTS AND COMPLIANCE COSTS FOR REFINERS AND CONSUMERS

MAR 25, 2019

FINAL REPORT

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EXECUTIVE SUMMARY

INTRODUCTION

This report, "***Denver Metro/North Front Range Fuel Supply Impacts and Compliance Costs for Refiners and Consumers – 2018 Study***", was prepared in response to the Denver Regional Air Quality Council (RAQC) request of an update to a similar study conducted by EAI, Inc. (Energy Analysts International) in 2011.

RAQC and other state government agencies are working together to evaluate strategies aimed at reducing ozone precursor emissions. One of these strategies includes the analysis of the impact of changes to motor gasoline specifications. The gasoline (CBOB - conventional gasoline blendstock for blending with ethanol) specification options being reviewed (and the focus of this study) include the following:

1. Maintain the current 7.8 psi (pound per square inch) RVP (Reid Vapor Pressure) summertime standard, but eliminate the one psi RVP ethanol waiver (CBOB_7.8_NWVR)
2. Adopt a 7.0 psi RVP summertime standard and retain the one psi RVP ethanol waiver (CBOB_7_WWVR)
3. Adopt a 7.0 psi RVP summertime standard without the one psi RVP ethanol waiver (CBOB_7_NWVR)
4. Eliminate summertime ethanol blending (ETOH_BLND_ELMN)

Currently, 7.8 psi RVP gasoline with a one psi ethanol waiver is used in the ozone nonattainment area (NAA or Denver NFR/DNFR). The gasoline specification changes are being evaluated for the NAA. This geographical region is defined below in **Figure ES-1**.

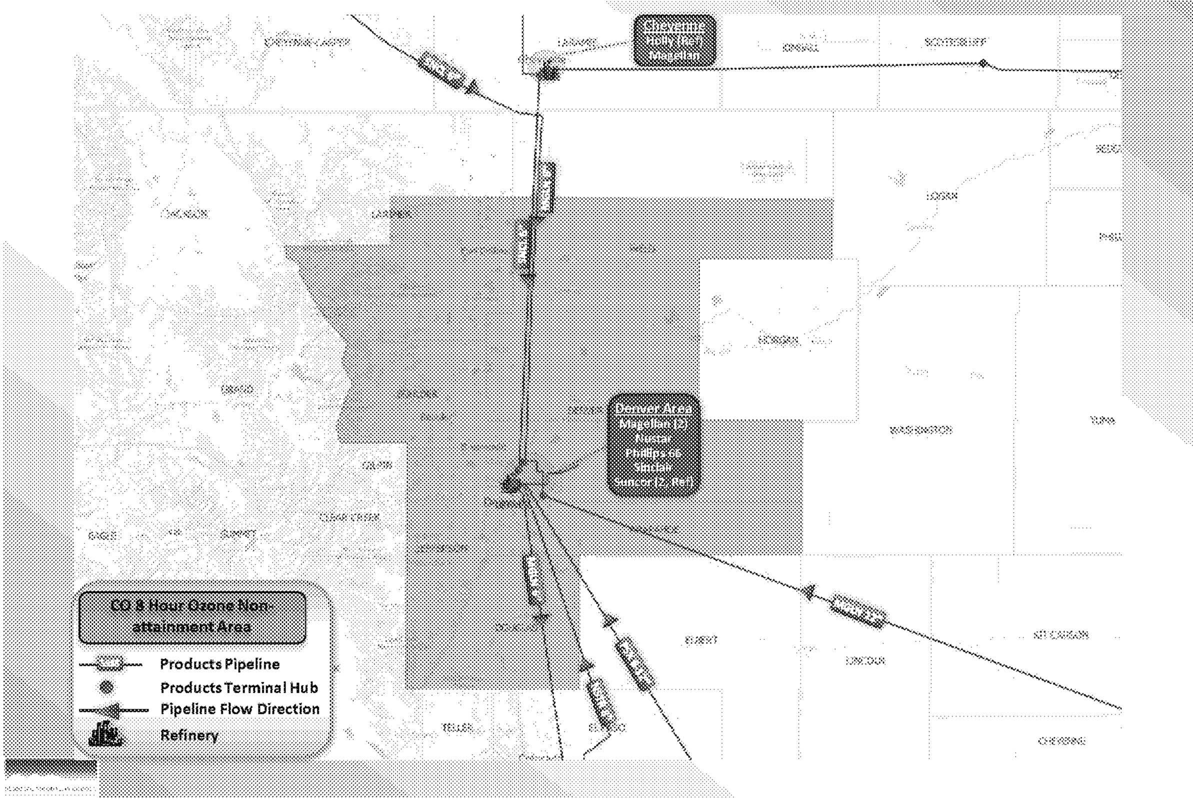
The NAA includes the highly populated areas extending from Castle Rock in the south, through Denver – Boulder and up to Fort Collins. As noted further on, this area is supplied with finished gasoline and gasoline blend stock to be blended with ethanol from a number of refineries located both within the area and external to the area.

A significant portion of the gasoline supplied in the Denver metro area is trucked out of the NAA and into the outlying ozone attainment areas.

Figure ES-1

EAI, Inc. Market Boundaries and Local Supply Network

CO Ozone Non-attainment Market Area (NAA or Denver NFR/DNFR)

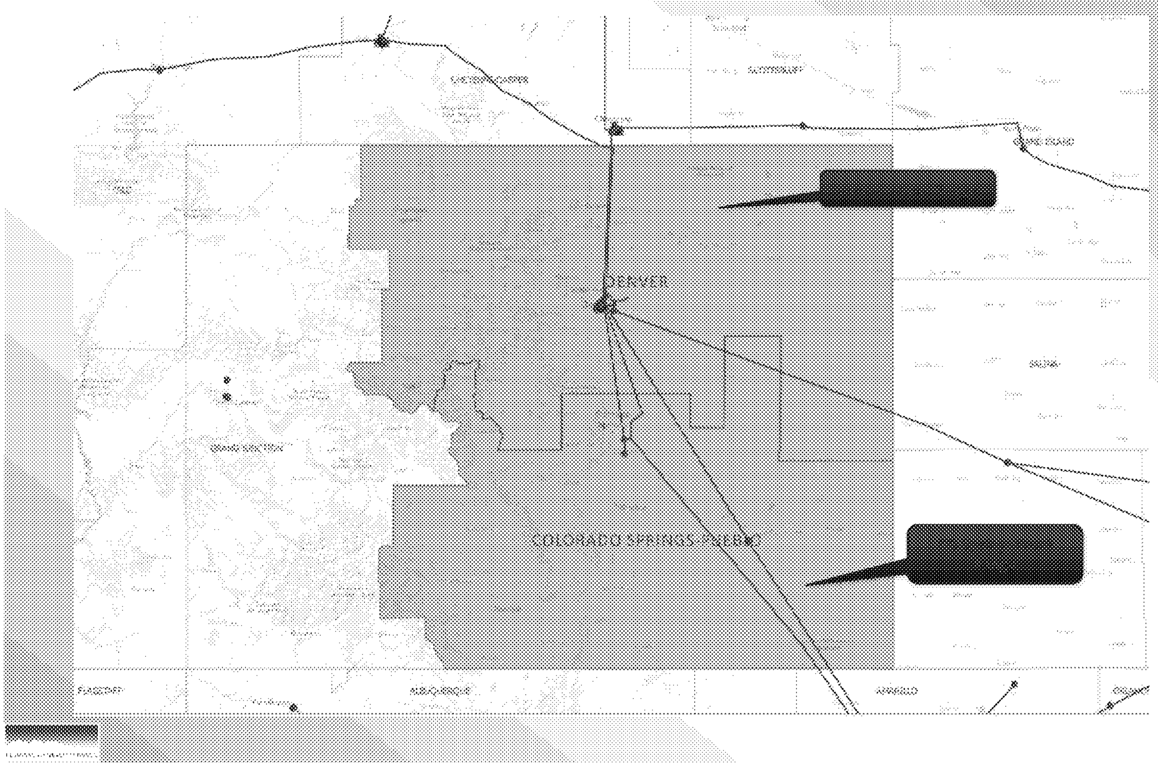


The purpose of conducting this study was to evaluate the potential impacts of switching to a more stringent formulation of summertime gasoline for this market and the surrounding areas (collectively referred to as the Colorado Front Range, or CFR – please see **Figure ES-2** below for geographical definition). These impacts can take a number of forms including additional gasoline supply costs due to increased manufacturing costs and changes in the sourcing of gasoline supply due to decisions made by refiners to not invest in the equipment and modifications needed to produce the more stringent gasoline specifications. Both of these situations can potentially add significant costs to the wholesale and consumer price of gasoline.

Figure ES-2

Colorado Front Range

Colorado Front Range composed of Denver – Front Range and the Colorado Springs – Front Range market areas.



STUDY AND STUDY PURPOSE OVERVIEW

RAQC has requested that the defined Scope of Work, Tasks 1 through 6 shown below be addressed in order to update the previous 2011 study performed by EAI, Inc. These tasks have been addressed through analysis and modeling conducted by the EAI, Inc. study team, and through survey work conducted by EAI, Inc. with each significant supplier of the CFR market.

Task 1: Summary of the Colorado Front Range Markets
Task 2: Capabilities of the Fuel Suppliers
Task 3: Cost and Distribution Impacts
Task 4: Ethanol and Biofuels Impacts
Task 5: Federal Rules Impacts
Task 6: Reports, Presentations, and Technical Support

The overall goal is to assess the market impacts of the various fuel strategies under evaluation, the costs incurred to make the designated fuel (capital and operating) and how a particular fuel specification may impact the sourcing and availability of summer gasoline for the CFR market. EAI, Inc., as part of its most recent work completed for RAQC, developed a supplier-refinery survey process including survey forms as well as a database structure to support the compilation and analysis of the survey data received from each refiner. A list of the refiner/refineries surveyed and their participation is shown in **Figure ES-3** below. Out of the 11 refinery surveys sent out, 8 were completed and returned.

Figure ES-3

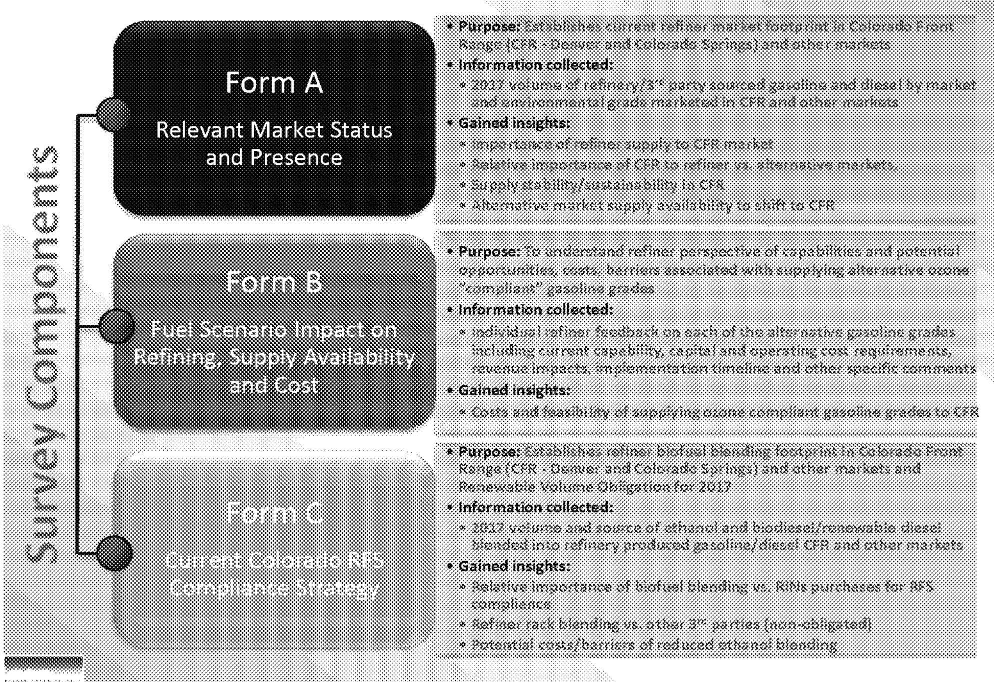
RAQC Fuel Study: Refiner Surveyees

Company	Refinery Site	State	Crude Oil Capacity, BPD
CHS	Laurel	MT	59,600
CHS	McPherson	KS	97,920
Exxon Mobil	Billings	MT	61,500
HollyFrontier	Cheyenne	WY	48,000
HollyFrontier	El Dorado	KS	160,000
Phillips 66	Billings	MT	60,000
Phillips 66	Borger	TX	146,000
Sinclair	Casper	WY	24,500
Sinclair	Rawlins	WY	75,000
Suncor	Commerce City	CO	103,000
Valero	McKee	TX	195,000

EAI, Inc. tweaked this process based on "lessons learned" from the 2011 study and the specific objectives of this new program. An overview of the overall structure of the survey, purpose, collected information, and insights gained are shown in **Figure ES-4** below.

Figure ES-4

RAQC Fuel Study: Refiner Survey 2018



EXECUTIVE SUMMARY-KEY TAKEAWAYS

The key takeaways from this study are summarized below and addressed in more detail in the Expanded Executive and Component Summary and base study documents that follow.

Market Area Impacted: Gasoline demand in the overall Denver-Front Range (DFR) area, which extends from Pitkin County north to the state border and East to the KS border, is 113 MBPD (thousand barrels per day) consisting of 93 MBPD in the NAA and 20 MBPD outside of the NAA. The significance of these boundaries is that most of the gasoline supplied to this entire area has to move from or through the non-attainment area.

Refinery and Supply Chain Structure Impacted: The CFR market is predominantly supplied by six petroleum refineries – one in state (Suncor) and five out-of-state (WRB Borger, HollyFrontier El Dorado, HollyFrontier Cheyenne, Sinclair Rawlins and Valero McKee) which supply the CFR via five refined product pipelines. Secondary sources of supply to the CFR market originate at other refineries in Billings, MT, Casper, WY, and the Midcontinent (MC) and Gulf Coast (GC) regions. The CFR market is the dominant gasoline market outlet for two of these refineries. The five product pipelines supplying the market operate at relatively high utilization rates during the ozone nonattainment, peak gasoline demand season.

Gasoline Supply Cost Impacts-Total Volume Weighed Average Cost Basis: These costs represent all refinery survey respondents and their respective supply in the market and ranged from 3.7 to 14.2 CPG (cents per gallon) for the Less Capital Intensive response scenarios to 6.2 to 13.3 CPG for the More Intensive Capital Intensive response scenarios. The lowest cost option was the 7 psi CBOB with a 1 psi ethanol waiver and the highest cost option was the ethanol blending elimination strategy. These relative cost rankings were the same for both the Low Capital and High Capital Intensive scenarios.

Gasoline Supply Cost Impacts-Max and 2nd Max Supply Costs: EAI, Inc. evaluated the Maximum supplier cost as well as the 2nd Max supplier cost to assess the incremental supply cost for the NAA. With refineries running at high utilization and the CFR market limited on the number of suppliers relative to other markets, it is likely that the Max and 2nd Max levels represent market clearing prices for these new gasoline specifications. The 7.8 and 7.0 psi with no waiver have Max and 2nd Max costs in the range of 14.5 to 21.0 CPG. However, the refinery inputs for these cases were limited as two of the respondent refiners indicated they would not be able to produce or supply the 7.0 with no ethanol waiver (NWVR) gasoline and would have to do some combination of shifting 9.0 psi RVP gasoline to other markets and reduce refinery output of product that could not be placed. The 7.0 psi gasoline option with waiver had Max-2nd Max costs in the range of 11.8 to 19.0 CPG.

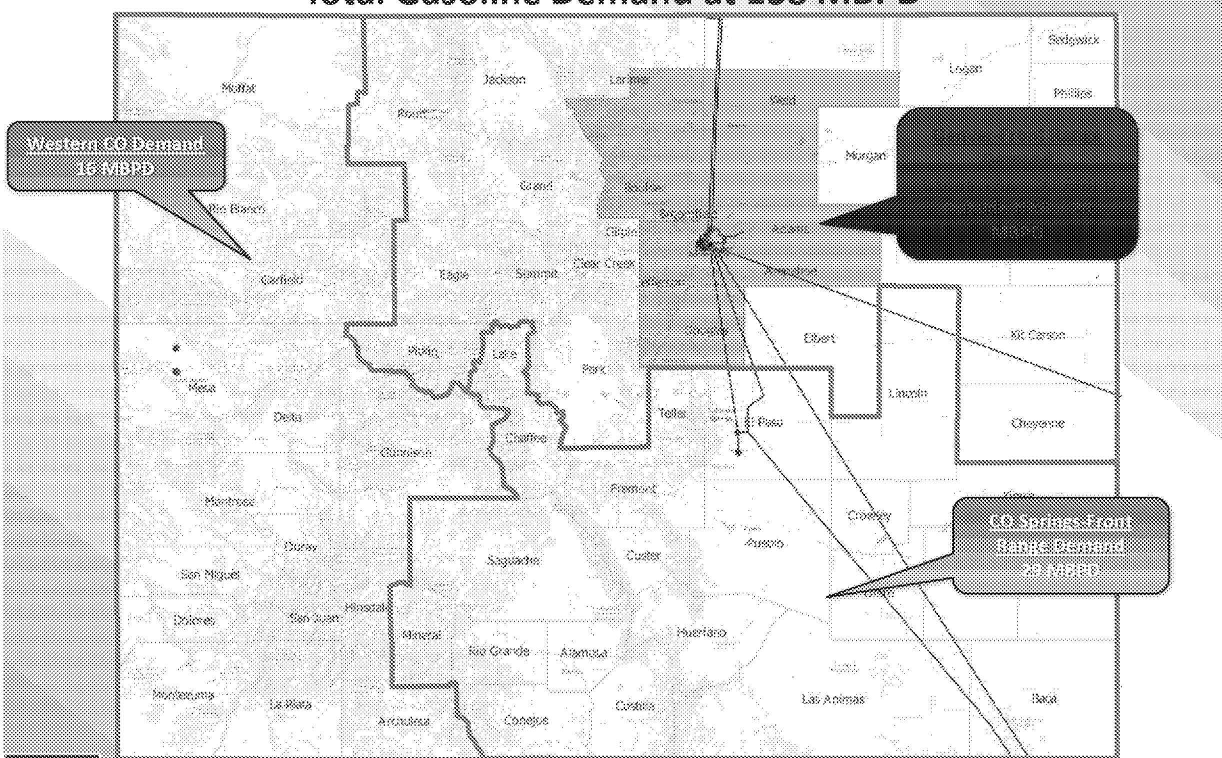
EXPANDED EXECUTIVE AND COMPONENT SUMMARY

GASOLINE DEMAND AND SUPPLY STRUCTURE IN THE ROCKY MOUNTAIN REGION AND CFR MARKET

An overview of the state of Colorado and the Denver Metro/North Front Range program area is shown in **Figure ES-5** with estimates of gasoline consumed in the various sub-regions. Total Colorado gasoline demand was 158 MBPD in 2017 (latest full calendar year of data available when the analysis for this study was being completed). EAI, Inc.'s forecast for gasoline demand in Colorado is for it to have peaked in 2017-2018 and then decline to 155 and 144 MBPD by 2020 and 2025, respectively. The overall Denver Metro/North Front Range area demand from Pitkin County north to the state border and East to the KS border is 113 MBPD consisting of 91 MBPD in the NAA and 20 MBPD outside of the NAA as estimated using EAI, Inc.'s Micro-Market Demand Model. The total gasoline demand in the Western Colorado and Colorado Springs – Front Range markets is roughly 16 and 29 MBPD, respectively. Ethanol consumption in the CFR market was 15 MBPD, or about 10% of the gasoline pool in 2017. Biodiesel supply has grown and now accounts for approximately 4% of the diesel pool.

Figure ES-5

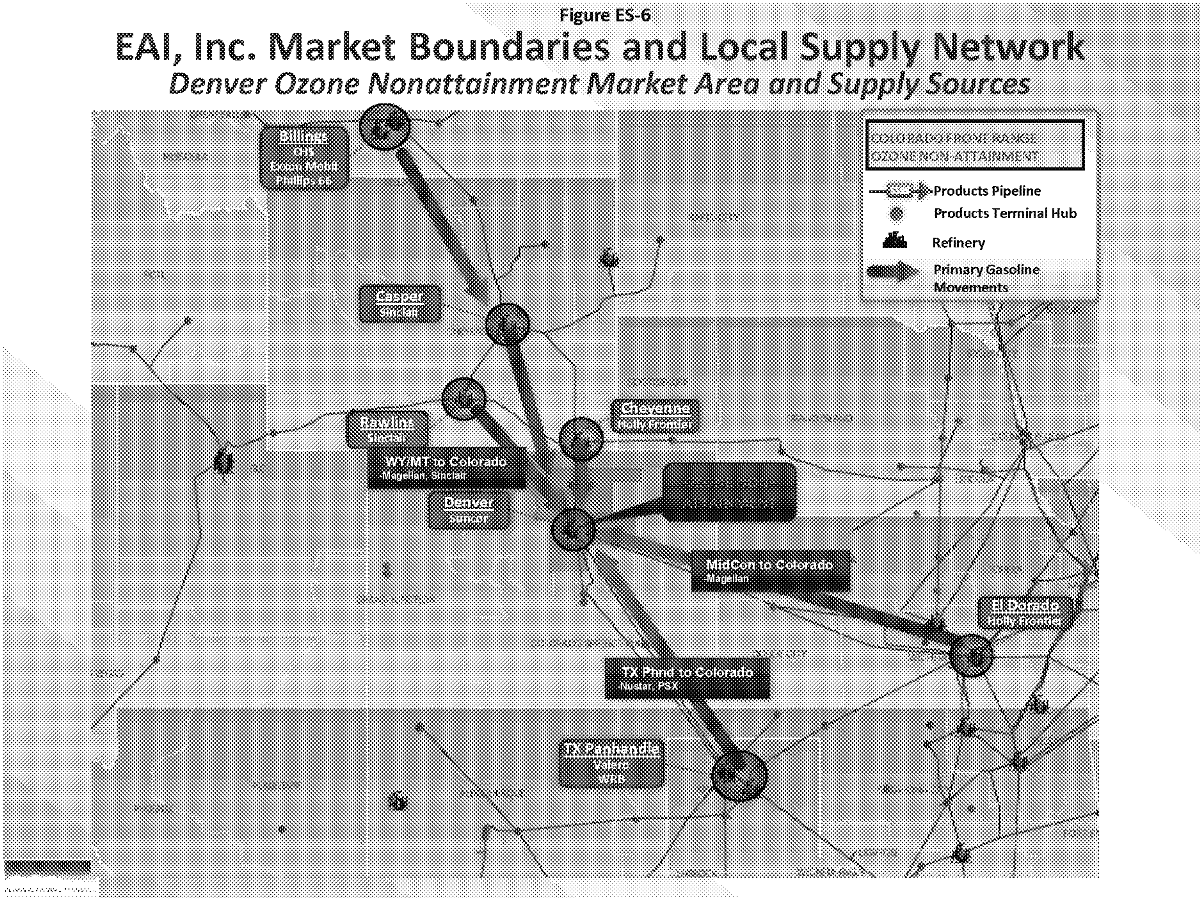
Gasoline Demand Distribution
Colorado by Geography and Ozone Attainment Status, 2017
Total Gasoline Demand at 158 MBPD



Source: EAI, Inc. analysis

The CFR market is predominantly supplied by six refineries – one in-state (Suncor) and five out-of-state (WRB Borger, HollyFrontier El Dorado, HollyFrontier Cheyenne, Sinclair Rawlins and Valero McKee) which supply the CFR via five refined product pipelines. Secondary sources of supply to the CFR market originate at other refineries in Billings, MT, Casper, WY, and the Midcontinent and Gulf Coast regions. These refineries and product pipelines are shown in **Figure ES-6**.

Figure ES-6



A more detailed view of the refined product supply network for the Rocky Mountains and the CFR Range is shown in **Figure ES-7**. The Suncor refinery in Commerce City, CO is the only refinery directly located in the market. The Valero and WRB (Cenovus-Phillips 66) refineries supply the market via the 33 MBPD capacity Nustar and 42 MBPD capacity Phillips 66/Nustar product pipelines.

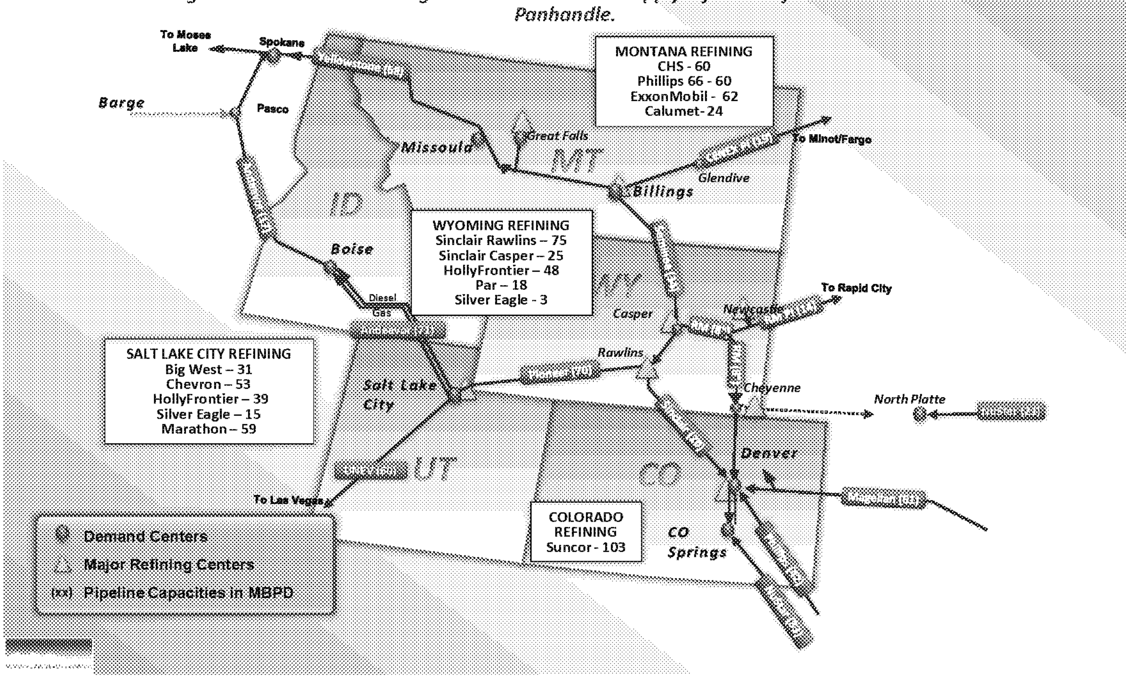
The HollyFrontier refinery in El Dorado, KS supplies the market via the 55 MBPD capacity Magellan-Chase pipeline. The HollyFrontier refinery in Cheyenne, WY supplies the market via the 25 MBPD capacity Magellan Mountain pipeline as well as via truck transport. Lastly, the Sinclair refinery at Rawlins, WY supplies the market via its Denver product pipeline which has an estimated capacity of 20 MBPD.

Figure ES-7

Refined Product Supply Network

Rocky Mountain Region

Rocky Mountain region is supplied by major refining centers in Colorado, Montana, Utah and Wyoming and a relatively simple network of product pipelines. Primary product export markets are to the West – Las Vegas and Eastern Washington. Colorado Front Range market has outside supply influences from the Midcontinent and Texas Panhandle.



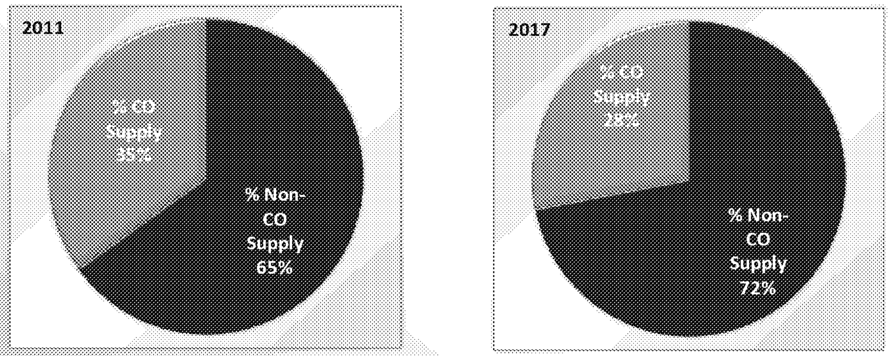
The Sinclair Little America refinery in Casper, WY and the three Billings area refineries (CHS, Phillips 66, and ExxonMobil) can and do supply product to the CFR market via pipeline, but in the recent past relatively little of this supply interaction has taken place. This is due to pipeline logistical limitations as well as tightness of product supply (and associated higher value) in the other Rocky Mountain markets north of Colorado.

Figure ES-8 below shows the change in supply between 2011 and 2017 from each of the major supplier groups outside of the CFR market.

Figure ES-8

Gasoline Supply Change to the Colorado Front Range Market

Colorado Front Range Gasoline Supply Change, MBPD (2011 vs. 2017)					
Region	*Supplier*	*Product*	*2011*	*2017*	*Delta*
WY_MT	HollyFrontier, Sinclair, Phillips 66, Other	GASO	27	36	9
ETOH	(Ethanol) Various	GASO	8	15	7
TX_PHNDL	WRB, Valero	GASO	34	40	6
CFR	Suncor	GASO	43	42	-1
MC_GC	HollyFrontier, Other	GASO	11	17	6



Source: EAI, Inc. analysis and interpretation of data from FERC, TX RRC, EIA, and Suncor 40-F report

The capacities and utilization rates of refineries supplying the CFR market have generally increased. With the exception of the local Suncor refinery, each supplier group significantly increased gasoline deliveries into the CFR market. The MC refiners tend to be the swing/incremental supply into the CFR market depending on prevailing economics and typically have more market optionality than other major CFR suppliers. Non-Colorado supply accounted for 72% of the total CFR supply in 2017 compared with 65% in 2011. An increase in non-CFR supply means there are more suppliers with a greater dependency on the CFR market for placing production, and thus potentially more widespread refining and supply impacts from a potential change in gasoline specifications. In addition, as supply has increased from sources located outside of the CFR, the respective logistical systems facilitating these movements have become more highly utilized on average. Ethanol supply has to be railed and/or trucked into the market as it cannot be transported on pipelines. A combination of increased Renewable Fuel Standards (RFS) as well as increased gasoline consumption overall has increased ethanol supply into the CFR market.

Figure ES-9 below shows the estimated 2017 pipeline capacity (MBPD), total loading (MBPD – gasoline, diesel, jet fuel), 2017 peak seasonal loading (MBPD), and pipeline peak utilization rate for the pipelines suppling the CFR market from the three major non-CFR supply sources (Wyoming – Montana, Texas Panhandle, Midcontinent-Gulf Coast). All of the major pipeline systems feeding Colorado from out-of-state supply sources are nearly fully utilized in the peak demand months of summer.

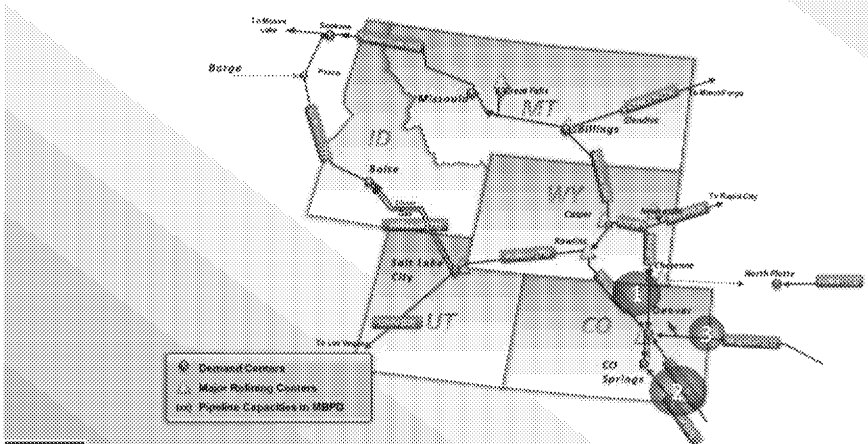
Figure ES-9

Refined Product Supply Network

CFR Pipeline Utilization

Colorado Front Range Pipeline Utilization (MBPD)						
Source Region	*Supplier*	*Pipeline(s)*	*Pipeline Capacity*	*2017 Total Loading*	*2017 Peak Seasonal Loading*	*Pipeline Peak Utilization*
1) WY_MT	HollyFrontier, Sinclair, Phillips 66, Other	Magellan (RMPL), Sinclair	45	45	45	100%
2) TX_PHNDL	WRB, Valero	Nustar, Nustar/Phillips 66	75	61	71	94%
3) MC_GC*	HollyFrontier, Other	Magellan (Chase)*	55	40	46	84%
ALL	ALL	ALL	175	146	162	92%

Midcontinent Gulf Coast supply tends to be the incremental supply source for CFR and generally experiences greater seasonal variation



Source: EAI, Inc. analysis and interpretation of data from FERC, TX RRC, EIA, and Suncor 40-F report

IMPACT OF GASOLINE SPECIFICATION CHANGES

Overall Refinery Impacts: A principle finding of this study is that each of the options under consideration has its own cost and fuel supply impacts and that the more stringent the fuel control scenario, the higher the cost. These cost components include: refinery capital costs, cost of refinery operation, lost product value due to rejecting higher value streams to lower value end uses, increasing supply costs due to companies shifting their product out of the CFR market to avoid investment.

Gasoline supplies were also more impacted under the more severe fuel options. Offsetting costs and supply impacts to varying degrees, the most stringent gasoline specification scenarios are expected to achieve the largest air quality benefit. The gasoline specifications being evaluated for the NAA will impact refiners in several ways depending on the fuel strategy option being considered and each refiner's plant configuration, operations and market options:

1) *Refinery Hardware Investments*

2) *Light Straight Run (LSR or Pentane Plus – C5/C6+) and Butane Rejection*

3) *Reduction of Compliant Gasoline for the DM/NFR NAA Market*

Modification/Implementation Schedule: Depending on the fuel option being considered and the company/facility and capital requirements, the schedule for implementation can range from minimal time requirements to 72 months. Based on the refiner survey responses, some companies opted for lower capital cost solutions involving a combination of retracting gasoline from the NAA and shifting supply to alternative (less stringent gasoline markets) as well as rejecting some light stream gasoline blend stocks and shifting these to lower value markets. However, collectively this is probably not a realistic response longer term given the supply disruption and market price increases that would potentially result. It is more likely that refiners would make larger investments to comply with the proposed fuel options and place more gasoline in the NAA market which would also help mitigate supply disruptions and significant price increases to the NAA.

This more realistic refiner response to the more stringent fuel options would require not only larger capital investments but also a longer schedule for implementation which could extend as long as 72 months for completion. Depending upon the fuel specification change, the refiners indicated the need for adequate time to implement capital investments and would require support from the state to ensure permitting and other requirements. To implement these more extensive modifications, there could be significant down time and other refinery impacts, which could also impact supply.

Other Potential Federal Fuel Changes and Integration: Refiners stressed the need for government transparency, decisiveness, and clarity regarding other potential federal regulations impacting fuel specifications such as the 95 minimum octane gasoline requirement, the Renewable Fuel Standard (RFS), and new changes to atmospheric ozone limits that would allow them to plan a cohesive response strategy that takes all of the relevant regulations into account. Ultimately, this would lead to more streamlined and cost-effective response strategies.

Basis for Total Incremental Production Costs: The average program costs per gallon includes estimates of incremental operating costs, incremental capital costs and lost value for shifting refinery light ends from a higher value gasoline market option to a lower value natural gasoline market (Conway, KS).

Total Cost Impact: The range of costs for the most realistic representation of refinery response is as follows (drawing on the Max and 2nd Max refiner-supplier costs covered in the base report in more detail):

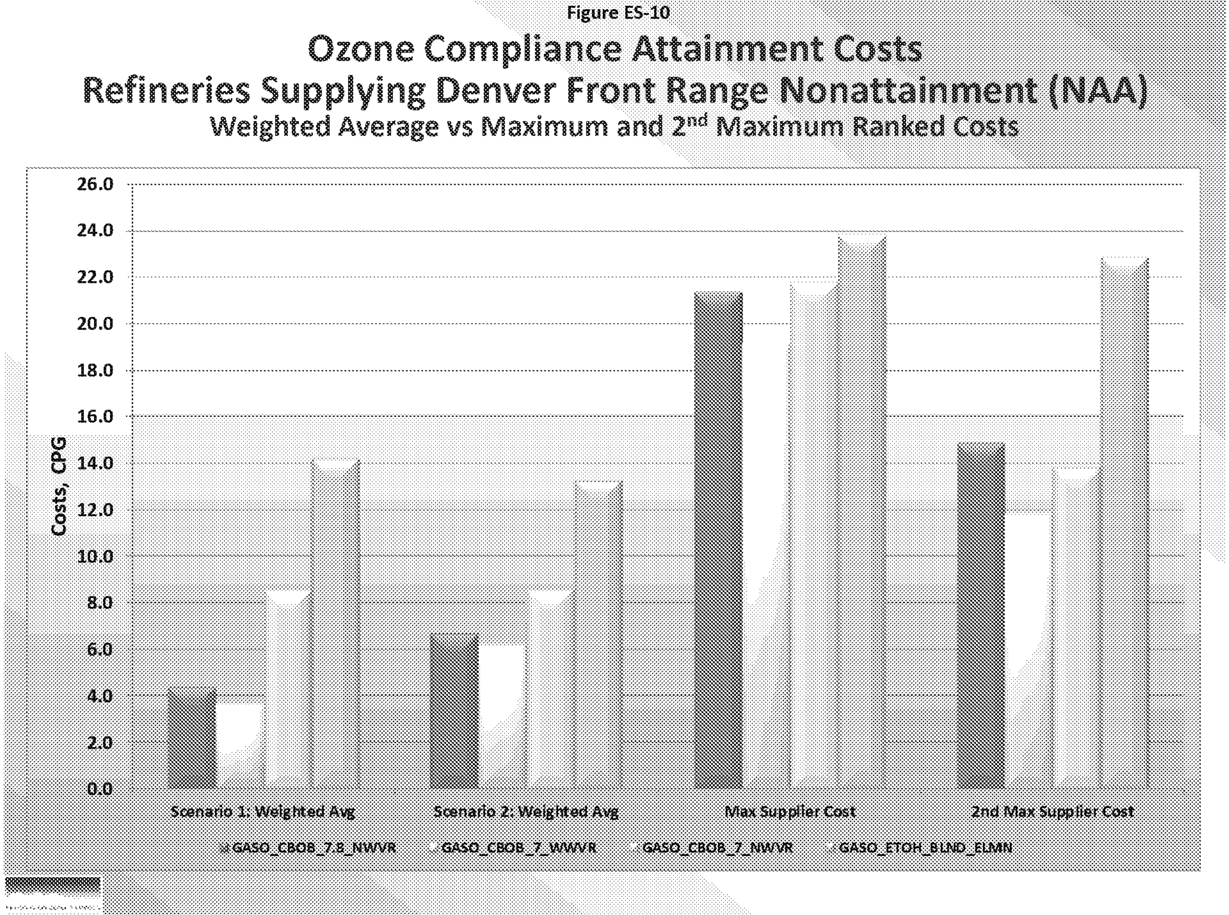
- *7.0 psi and 7.8 psi (with No Waiver)*: At 14.5 to 21.0 CPG, the 7.8 psi NWVR fuel option was very close to the 7 psi with the ethanol waiver (WWVR) case. The refinery survey inputs for the 7.0 psi NWVR case were limited as two of the respondent refiners indicated they would not be able to produce or supply the 7.0 psi NWVR gasoline and would have to do some combination of shifting 9.0 psi RVP gasoline to other markets and reducing refinery output of product that could not be placed.

- *7.0 psi with Waiver*: The costs representing the majority of the NAA gasoline volume was in the range of 11.8 to 19.0 plus CPG, which are less than the 7.8 psi NWVR and 7.0 psi NWVR cases. This includes a high of 2.0 CPG for incremental operating costs, 8.0 to 14.0 CPG for light-end rejection, and capital costs ranging from 0.7 to 2.2 CPG of output (based on amortizing capital costs over 10 years).

- *Eliminate Ethanol Blending*: This was the highest cost case in terms of capital expenditures, light end rejections and incremental operating costs with a range of 22.5 to 23.8 CPG for the Max and 2nd Max refinery-suppliers. It should be noted that RINs costs and purchase of iso-butane to offset the loss of ethanol blend component are likely significantly understated and the costs would be higher than indicated in the aforementioned figures.

Weighted Volume Costs Comparison of Compliant Fuel Option Costs: A summary of volume weighted refiner-supplier costs in response to the various fuel options being considered is summarized in **Figure ES-10** which illustrates comparative costs for the Lower Capital Cost and Higher Capital Cost Intensity Scenarios (SCNR_1 and SCNR_2, respectively).

Figure ES-10



As shown, these volume weighed costs are significantly less than the Max and 2nd Max costs presented previously representing, to some extent, the relatively wide range of impact the different fuel options will have across the different refiners that supply the NAA market. A more detailed summary of refining cost and supply impacts is shown in **Figure ES-11** below for all the cases considered and for both Capital Intensity Scenarios with some observations and insights for the various cost segments.

Figure ES-11

Ozone Nonattainment Fuel Cost (Weighted Avg.) and Supply Impacts

SCENARIO 1: LESS INTENSIVE CAPITAL EXPENDITURES

METRIC	STREAM	UNITS	SPLY 2017	CBOB_7.8_NWVR	CBOB_7_WWVR	CBOB_7_NWVR	ETOH_BLND_ELMN
COSTS	OPERATING COSTS	CPG		2.0	1.6	7.0	12.4
COSTS	CAPITAL COSTS	MM_$		57.0	57.0	25.0	25.5
COSTS	CAPITAL COSTS PER SUPPLIED GALLON	CPG		1.4	1.4	1.1	0.7
COSTS	BUTANE VALUE LOSS	CPG		0.1	0.0	0.3	0.0
COSTS	LIGHT STRAIGHT RUN (LSR) VALUE LOSS	CPG		0.9	0.6	0.1	1.0
COSTS	TOTAL BUTANE AND LSR VALUE LOSS	CPG		0.9	0.6	0.4	1.0
COSTS	TOTAL COSTS	CPG		4.4	3.7	8.6	14.2
OUTPUT	NATN SUPPLY	MBBLS	13638	13120	13157	7465	12067
OUTPUT	BUTANE REJECTION	MBBLS		205	168	264	71
OUTPUT	PENTANES PLUS REJECTION	MBBLS		912	742	175	971
OUTPUT	BUTANE AND PENTANES PLUS REJECTION	MBBLS		1117	910	439	1042
OUTPUT	LOST GASOLINE SUPPLY	MBBLS		819	668		915
OUTPUT	GASOLINE SHIFT TO OTHER MARKETS	MBBLS		16	11	1183	698
OUTPUT	GASOLINE SUPPLY LOSS (NATN)	MBBLS		835	679	5862	1613
SCHEDULE	MINIMUM PROJECT SCHEDULE DURATION	MONTHS		24	24	12	24
SCHEDULE	MAXIMUM PROJECT SCHEDULE DURATION	MONTHS		36	36	36	36

SCENARIO 2: MORE INTENSIVE CAPITAL EXPENDITURES

METRIC	STREAM	UNITS	SPLY 2017	CBOB_7.8_NWVR	CBOB_7_WWVR	CBOB_7_NWVR	ETOH_BLND_ELMN
COSTS	OPERATING COSTS	CPG		2.2	1.7	7.0	12.4
COSTS	CAPITAL COSTS	MM_$		152.0	152.0	25.0	25.5
COSTS	CAPITAL COSTS PER SUPPLIED GALLON	CPG		4.2	4.2	1.1	0.7
COSTS	BUTANE VALUE LOSS	CPG		0.1	0.0	0.3	0.0
COSTS	LIGHT STRAIGHT RUN (LSR) VALUE LOSS	CPG		0.3	0.2	0.1	0.1
COSTS	TOTAL BUTANE AND LSR VALUE LOSS	CPG		0.4	0.3	0.4	0.1
COSTS	TOTAL COSTS	CPG		6.7	6.2	8.6	13.3
OUTPUT	NATN SUPPLY	MBBLS	13638	12193	12136	7465	12067
OUTPUT	BUTANE REJECTION	MBBLS		207	179	264	71
OUTPUT	PENTANES PLUS REJECTION	MBBLS		303	226	175	971
OUTPUT	BUTANE AND PENTANES PLUS REJECTION	MBBLS		510	357	439	1042
OUTPUT	LOST GASOLINE SUPPLY	MBBLS		1745	1689	0	915
OUTPUT	GASOLINE SHIFT TO OTHER MARKETS	MBBLS		16	11	1183	698
OUTPUT	GASOLINE SUPPLY LOSS (NATN)	MBBLS		1761	1700	5862	1613
SCHEDULE	MINIMUM PROJECT SCHEDULE DURATION	MONTHS		36	36	36	24
SCHEDULE	MAXIMUM PROJECT SCHEDULE DURATION	MONTHS		36	36	36	36

The low RVP gasoline season lasts between May 1st and September 15th at bulk supply terminals

Capital Cost Impacts: Total industry capital costs to comply with the various gasoline grades being considered is in the range of $25 million for the CBOB 7 psi NWVR and "eliminate ethanol blending" cases to $57 million for the 7.8 NWVR and 7.0 WWVR cases for the Low Capital Intensity cases. The capital costs for industry in response to the fuel options being considered increases to $152 million for the High Capital Intensity scenarios and the 7.8 NWVR and 7.0 WWVR fuel options.

Operating Cost and Lost Light End Value: It should be noted that operating costs, increasing opportunity costs, and higher costs for increasing gasoline blendstocks are not distinguished enough across the refinery surveys to accurately define and differentiate actual incremental refinery operating costs from these other incremental costs. The butane and LSR rejection costs, however, are fairly representative of opportunity costs.

Increasing rejection of these components is required with lower RVP requirements and specifying no 1 psi blending waiver for ethanol. This represents a major increasing cost burden and risk for refiners with considerable uncertainty in the ability to place these streams in the market in the future and the value to be realized.

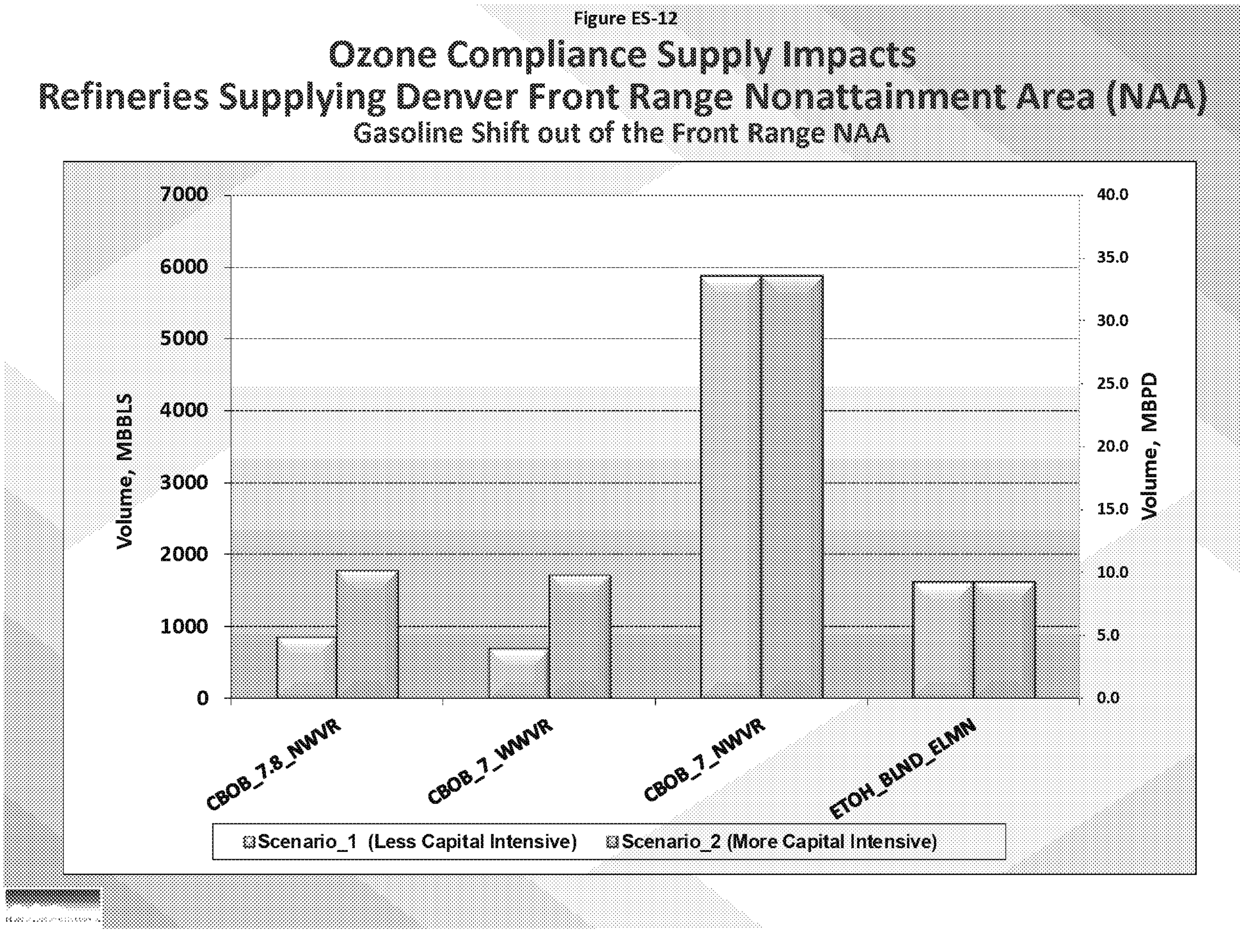
The High Capital Intensity cases represent, to some extent, refiners reducing their LSR/pentane plus market exposure as mentioned above. With increasing LSR marketing risk and lower value realization, refiners will likely be forced to invest in processes to convert the LSR/pentane plus materials to higher value products. As mentioned this is part of what is being pursued with the Higher Capital Intensity refinery responses but with the burden of creating another risk in being able to push a significant amount of incremental 9.0 psi gasoline to other markets. Some of this incremental 9.0 psi gasoline, which is mainly concentrated in the Eastern Rockies, could be directed to displace other sources of the same grade. This would have to be offset with increasing "imports" of compliant DM/NFR NAA gasoline from the other refiners that can access this market.

Impact on Supply Options: Some of the evaluated fuels in the Colorado Front Range will most likely sever supply linkage with refiners north of Casper, i.e. Billings and refiners east and, south of El Dorado, Kansas. There is some open pipeline capacity to increase product movements into the CFR/NAA but it is limited.

The general availability of the gasoline grades being considered by the RAQC is limited in these alternative product sourcing areas and any upsets in the base supply for the NAA would be very difficult to replenish and would result in considerably higher end market costs than represented in the supply-cost analysis represented previously.

Potential Supply Loss: The Colorado Front Range is likely to experience a decline in available gasoline supply from current supply sources due to two major factors:

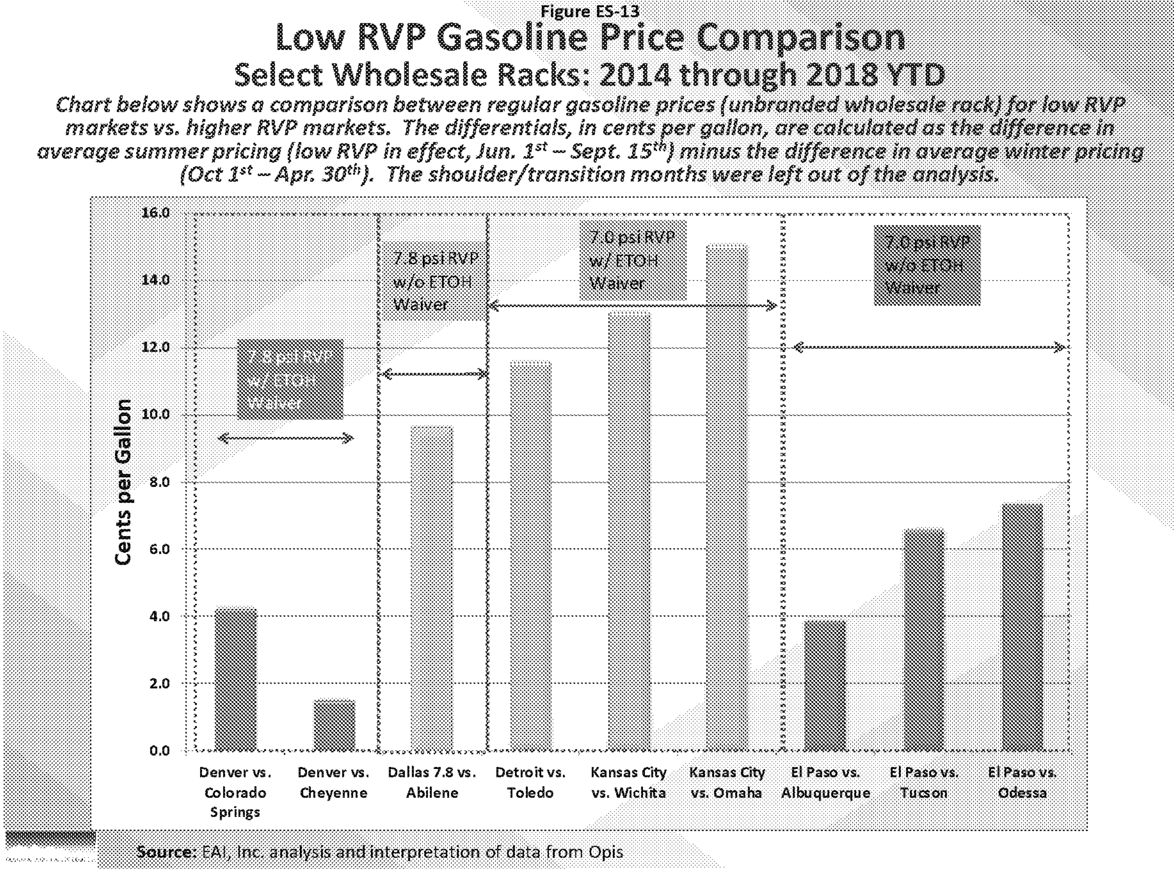
- Rejection of light ends (butanes & pentanes plus) to meet gasoline pool RVP limits. This volume is estimated to be in the range of 5 to 8 MBPD for the Low Capital Intensity scenarios and depending on the number of days assumed for the LRVP gasoline season. The Higher Capital Intensity scenario indicated less butane/LSR rejection with values more on the order of 2-4 MBPD. The "eliminate ethanol blending" case for both Capital Intensity Scenarios was the same at 6-8 MBPD during the low RVP season. A portion of this may be covered by increased ethanol blending either from ethanol blended into gasoline that is not blended now or via an increase in allowable ethanol blends, e.g. E15, increasing crude runs and/or producing other gasoline blendstocks such as isomerate and alkylate that would allow the use of greater quantities of lighter blendstocks.
- Some refiners have access to other markets and may shift gasoline to these markets to avoid the required capital investments in manufacturing some of the more stringent gasoline specs being considered for the CFR market. The range of potential gasoline loss due to market shift is 4 to 11 MBPD across all the cases considered except the 7.0 NWVR case for which the potential lost supply to the DM/NFR NAA is on the order of 35-40 MBPD (see **Figure ES-12**).



Supply Availability and Impact on Market Prices: Higher prices for low RVP gasoline is influenced by increased refinery manufacturing cost and generally more restrictive supply availability. EAI, Inc.'s analysis indicates that there have often been 1.5 to 15.0 CPG market premiums paid for lower RVP fuels relative to 9.0 psi gasoline (see **Figure ES-13**) depending on the RVP specification.

The CFR market already experiences short term, summer price increases (relative to Gulf Coast spot) and these would likely increase with a more stringent gasoline RVP specification. The CFR market tends to be more isolated than these other markets used in the comparison analysis and is likely to experience at least these levels of price increases related to the incremental cost of gasoline meeting the specifications of the evaluated strategies.

Figure ES-13



Source: EAI, Inc. analysis and interpretation of data from Opis

Retail Pricing Response to Increasing Wholesale Prices: With supply being generally tight during the early stages of the program (first two to three years), it is likely that the incremental wholesale gasoline costs will be supported by the retail sector and passed on to the consumer. Some of the wholesale price increase could be mitigated somewhat by competing forces at the retail level as operators stay competitive to maintain store traffic and in-store sales. This is especially true in markets that have a relatively high population of hypermart stores selling gasoline as does the Denver market.

Supply Distribution Response: Refiners with significant alternative market options include WRB Borger, Valero McKee and HollyFrontier, El Dorado. These refineries have alternative markets of significant size and have product pipeline connections to these markets; however some are somewhat logistically limited and economically less attractive. Similarly, these same refineries in supplying significant volumes to alternative markets can choose to retract product from the alternative markets and send these volumes to Denver up to available pipeline capacity to replace reductions in supply by other refiners serving the market.

Refineries with limited alternative market options include Suncor Denver and the HollyFrontier Cheyenne refineries. These refineries place a very large portion of their product in the CFR market area and if they did not invest to produce lower RVP gasoline (if mandated) then they would ultimately need to invest in new logistics/higher transportation costs to access alternative markets. These refineries are a key supply source for the CFR market. Loss of this volume via a decision to not make the more expensive, lower RVP gasoline product would be difficult to replace on a short term basis.

In general, this replacement product would have to come from HollyFrontier El Dorado, WRB Borger and Valero McKee refineries with additional product being sourced in the Texas – Western Louisiana Gulf Coast area via Explorer and Magellan pipeline systems. In order for replacement supply to be accessible from the Gulf Coast, Magellan Midstream Partners would have to make investments in tankage for their pipeline system to accommodate lower RVP gasoline moving from the Gulf Coast through Tulsa and to Denver. Lastly, Sinclair Rawlins refinery places a significant amount of gasoline into the CFR market, but could potentially shift that supply to alternative markets such as Salt Lake City and Las Vegas.

Responses to the changes in gasoline grade specifications can take a number of forms including decisions to not supply the CFR market and reduction in the volume of specification grade gasoline and hence the volume supplied. Impacts of these decisions may be observed as retraction of attainment area gasoline from outlying markets, higher prices for gasoline product in the nonattainment area versus the attainment area, attainment area gasoline prices rising to levels similar to those in the nonattainment area and experiencing supply-price upsets due to shrinkage in available fungible Denver/Front Range spec gasoline.

Ethanol Blending Elimination Impacts: One of the options for gasoline emissions reduction is the banning of ethanol usage during the ozone season. Banning ethanol blending during the ozone season would conflict with the requirements of RFS as established under the Energy Policy Act of 2005 and later expanded under the Energy Independence and Security Act of 2007. Under the RFS, refiners in the United States are required to blend a certain amount of renewable fuels into the transportation fuels that they produce during a given year. Accordingly, banning the use of E10 in the nonattainment area during the ozone season would prevent refiners serving the area from complying with their legal obligations under the federal RFS.

Ethanol has evolved into a very important blending component for refiners even when excluding the RFS incentive to blend. Typically, refiners supply regular “subgrade” gasoline to the CFR market which typically has a posted octane number (PON - average of the research and motor octane numbers) of 81 to 82, whereas regular gasoline at the pump typically has a PON of at least 85.

Blending 10% ethanol into gasoline gives refiners a 3 to 4 octane point boost on average. This is typically a more economical way to produce octane than refinery-centric methods such as the operation of reformer units at higher severity. In addition, ethanol as a blending component is typically less expensive than the going market rate for gasoline, meaning refiners/suppliers can realize a “blending margin” by blending ethanol.

Eliminating the blending of ethanol in the CFR nonattainment area would increase costs to the refiner/supplier which would ultimately be passed through to consumers. Some of the primary cost and other impacts associated with eliminating ethanol blending include:

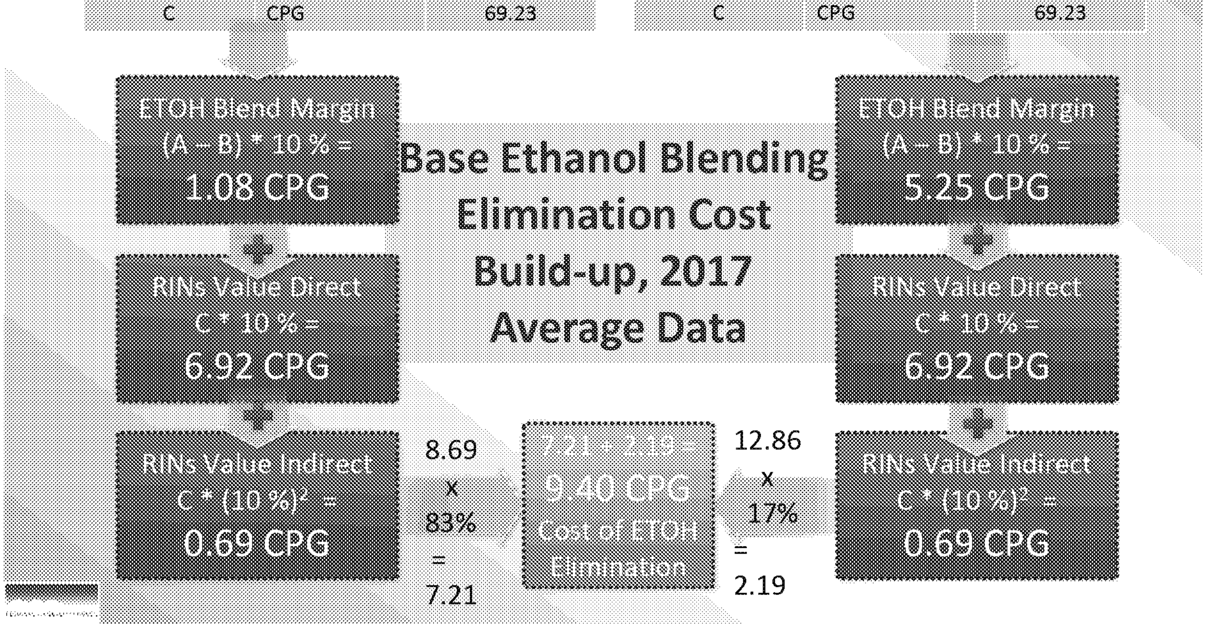
1. **RINs credit purchase requirement**
2. **Lost ethanol blending margin**
3. **RINs credit indirect purchase requirement as a result of replacing lost ethanol with gasoline**
4. **Associated octane loss and replacement cost**
5. **Loss of significant ethanol market for ethanol producers**
6. **Replacement supply logistics constraints**
7. **Terminal tank storage limitations**

EAI, Inc. quantified factors 1 through 3 for the CFR nonattainment market as a whole taking into account both regular and premium gasoline consumption in the market. The estimated minimum cost of ethanol blending elimination as shown below in **Figure ES-14** would be 9.4 CPG (cents per gallon). This cost was calculated using 2017 average annual unbranded wholesale rack pricing for Denver (from OPIS), D6 RINs pricing (from Argus), NE spot ethanol pricing (from Argus), and EAI, Inc.'s estimate for ethanol rail transportation from Omaha, NE (where Argus spot pricing is based).

Figure ES-14

Regular Gasoline: 83% of NAA Consumption		
A	Denver Reg. Rack Price, CPG	171.72
B	ETOH Laid-in Cost, CPG	160.93
C	D6 RIN Value, CPG	69.23

Premium Gasoline: 17% of NAA Consumption		
A	Denver Prem. Rack Price, CPG	213.47
B	ETOH Laid-in Cost, CPG	160.93
C	D6 RIN Value, CPG	69.23



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Federal Environmental Mandates, Boutique Gasoline Products and Fungibility: Although a number of markets have relaxed maximum gasoline RVP specifications in recent years as they have come into ozone attainment, it is possible additional markets could adopt low RVP gasoline specifications as more stringent ozone regulations are enforced in the coming years. In October 2015, the EPA finalized revisions to the NAAQS for ground-level ozone concentrations and strengthened the standard from 75 ppb to 70 ppb on October 1, 2015. When the 75 ppb level was set in March 2008, 168 counties in 17 states were classified as nonattainment areas. With the new 70 ppb concentration level, 200 counties in 22 states would be classified as nonattainment according to 2014-2016 monitoring data.

In general, if more markets implement lower RVP gasoline specifications, product will be in greater supply and accessible to markets from more refinery options. Benzene reduction implementation (for MSAT2) generally made it more difficult to meet minimum octane specification in gasoline as the benzene and other aromatic compounds being taken out of the gasoline or saturated with hydrogen are typically higher octane components with relatively low RVP. The increasing RFS has essentially required ethanol blending and thus producing gasoline blendstocks with low enough RVP to absorb the RVP bump and meet maximum specifications. However, as a result ethanol has become an important source of octane and thus more difficult to eliminate as mentioned previously.

OV

OVERVIEW OF THE COLORADO AND FRONT RANGE FUELS MARKET

INTRODUCTION

The Colorado Front Range (CFR) area consists of dynamic, complex, and interlocked markets that are rather distinct from the surrounding market areas in terms of refined product supplier mix, supply access, and market-specific grades. The CFR markets are relatively isolated from large refined product supply hubs like the Gulf Coast (Houston-Beaumont) and thus are reliant on a relatively small number of supply sources.

Six major refineries and five major product pipelines supply the CFR area. Other swing refineries and ancillary pipelines are capable of providing some additional product. Five of these refineries are located out-of-state, while the sixth, the Suncor refinery, is located in Commerce City. The local Suncor Commerce City refinery is the largest single supplier to the CFR markets.

Of the other five refineries, two, both in Wyoming are also primarily oriented to supplying the CFR markets. The other three, two in Texas, and one in Kansas supply products to multiple markets, with the CFR markets being only one of their major market outlets. These latter refineries have the flexibility to supply the markets that are most attractive business-wise.

Because of past ozone violations, the Denver area has been designated as a low summertime gasoline volatility area, with base gasoline having a maximum Reid Vapor Pressure (RVP) of 7.8 pounds per square inch (psi) with the adoption of the current eight-hour ozone State Implementation Plan (SIP). Outside of the Denver/North Front Range areas, a more volatile summertime gasoline of up to 9.0 psi RVP is permitted.

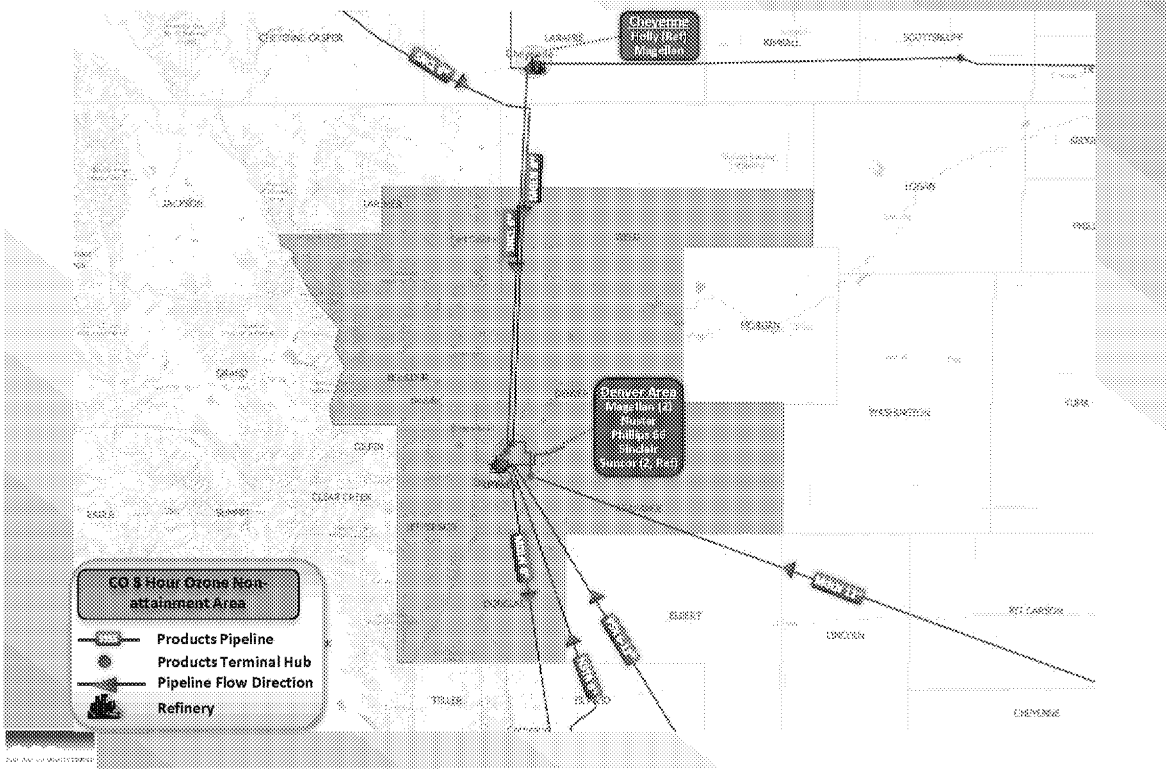
The Denver – Boulder – Greeley – Fort Collins eight hour ozone control area or ozone non-attainment area (NAA) within the existing gasoline distribution areas of Colorado is shown in **Figure OV-1.** This area encompasses major portions of the CFR market and includes both major populated areas (Denver, Boulder, Fort Collins, Castle Rock and Greeley) and also a larger control area that includes areas of eastern, northeastern and northern Colorado.

Counties included in this area are Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer and Weld. Other gasoline market areas in Colorado include the Colorado Springs Front Range market area to the south and the Grand Junction – Western Slope market area to the west.

Figure OV-1

EAI, Inc. Market Boundaries and Local Supply Network

CO Ozone Non-attainment Market Area (NAA or Denver NFR/DNFR)

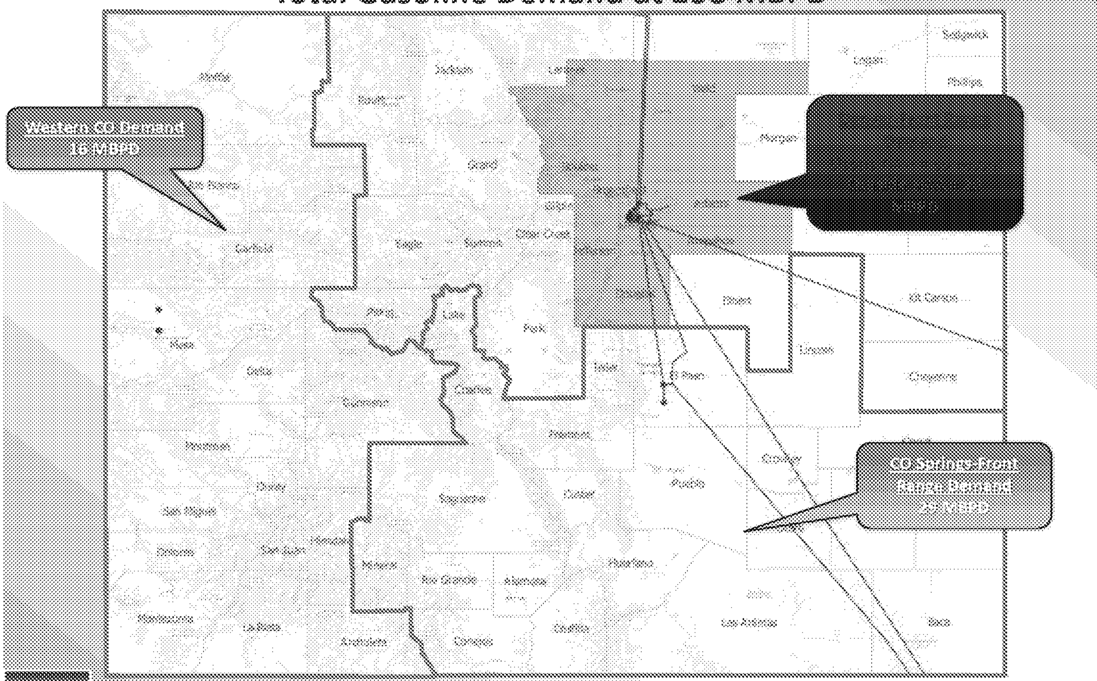


GASOLINE DEMAND IN COLORADO

An overview of the state of Colorado and the Denver Metro/North Front Range program area are shown in **Figure OV-2** with estimates of gasoline consumed in the various sub-regions. Total Colorado gasoline demand was 158 MBPD 2017. EAI, Inc.'s forecast for gasoline consumption in Colorado is for gasoline demand to have peaked in 2017-2018 and then decline to 155 and 144 MBPD by 2020 and 2025, respectively.

The overall Denver-Front Range area demand from Pitkin country north to the state border and East to the KS border is 113 MBPD consisting of 93 MBPD in the NAA and 20 MBPD outside of the NAA. The total gasoline demand in Western Colorado and Colorado Springs – Front Range is roughly 16 and 29 MBPD, respectively.

Figure OV-2
Gasoline Demand Distribution
Colorado by Geography and Ozone Attainment Status, 2017
Total Gasoline Demand at 158 MBPD



Source: EAI, Inc. analysis

Rocky Mountain gasoline consumption has grown significantly following a period of declining-to-flat consumption between 2005 and 2012. An improving economy and net inbound migration combined with consumer response to lower oil and gasoline prices beginning in 2015 contributed to gasoline consumption increasing from 313 to 353 MBPD (thousand-barrels per day) between 2012 and 2017.

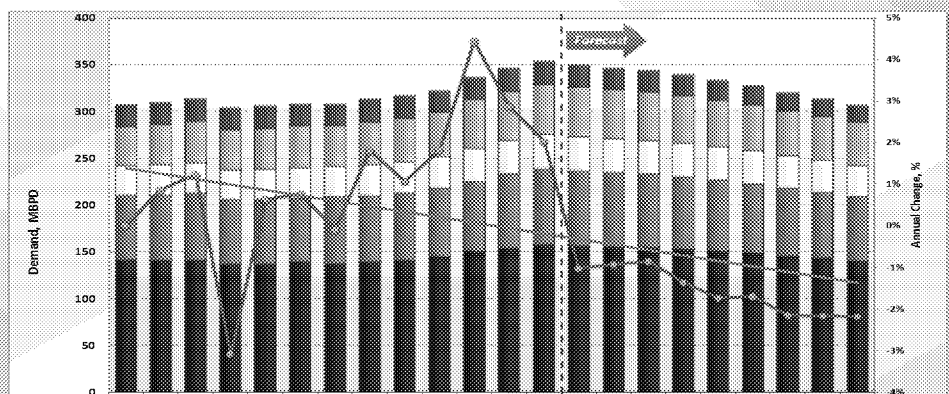
The state of Colorado was the recipient of much of this consumption growth. Significant growth in business activity, population, and vehicle miles traveled in response to relatively low oil prices contributed to gasoline consumption in Colorado increasing from 140 to 158 MBPD between 2010 and 2017. **Figure OV-3** below shows historic and forecast gasoline consumption growth for the Rocky Mountain region.

Figure OV-3

Demand Trends & Forecast: *U.S. Rocky Mountains*

Total Gasoline Pool: State Level

- *Total gasoline demand was declining-to-flat from 2007 to 2012 but responded to lower prices and economic/population beginning in 2015 with demand increasing from 322 to 353 MBPD from 2014 to 2017*



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
WY	23	24	24	23	24	23	22	24	24	23	24
ID	41	43	44	43	43	45	44	46	46	47	52
MT	32	33	33	32	32	33	32	33	33	34	35
UT	69	69	72	69	69	67	71	71	72	73	75
CO	142	141	141	137	137	140	138	139	141	145	151
TOTAL RM	307	310	313	304	306	308	308	313	317	322	337
TOTAL RM %	0.0%	0.9%	1.2%	-3.1%	0.6%	0.8%	-0.1%	1.8%	1.1%	1.8%	4.4%

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
WY	25	24	24	23	22	22	21	20	19	18	18
ID	52	53	53	52	52	51	50	49	48	47	46
MT	36	37	37	36	36	36	36	35	35	34	33
UT	80	81	80	79	79	77	76	74	72	71	69
CO	154	158	157	156	155	153	151	149	146	143	140
TOTAL RM	346	353	350	347	344	339	333	327	320	313	307
TOTAL RM %	2.9%	2.0%	-1.0%	-0.9%	-0.9%	-1.4%	-1.7%	-1.7%	-2.2%	-2.2%	-2.2%

Source: EAI, Inc. analysis and interpretation of data from EIA and state departments of transportation

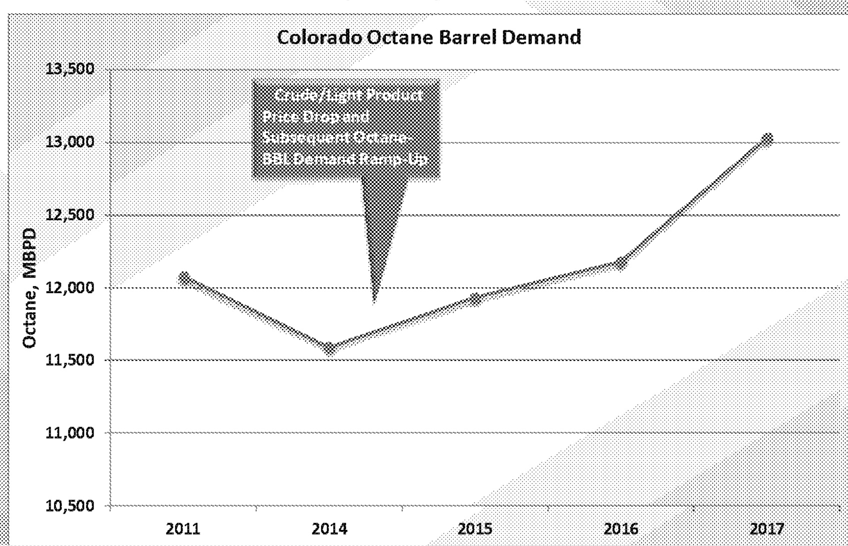
Premium gasoline (>= 91 posted octane number) sales as a fraction of total gasoline sales have increased as well, increasing from 12% to 17% between 2011 and 2017. **Figure OV-4** shows the corresponding increase in octane barrel demand.

Figure OV-4

Colorado Octane-Barrel Demand Trends

Total Gasoline Pool: 2011 through 2017

Octane-barrel demand increasing due to relatively low crude/light product prices and increasing penetration of turbo charged vehicles into the fleet and their requirement or recommendation to use premium gasoline.



Source: EAI, Inc. analysis and interpretation of data from EIA

A combination of relatively low fuel prices and the increasing penetration of new vehicle models with higher engine compression ratios requiring premium, or higher octane gasoline, are the primary contributors to increased premium gasoline and octane barrel demand. As shown in **Figure OV-5**, over half of new vehicles for model year 2018 have higher compression turbo-charged engines which typically require higher octane premium gasoline.

The number of turbo-charged models has been increasing rapidly as they offer a compromise of power and fuel economy and are better suited to meeting both CAFÉ and consumer demands. Refineries typically rely on the gasoline components reformate (more produced by running the reformate unit at higher severity) and alkylate (produced from the alkylation unit) to increase octane in the final gasoline blend. However, these components are generally costly and limited by the respective unit capacity and quantity of suitable feedstocks.

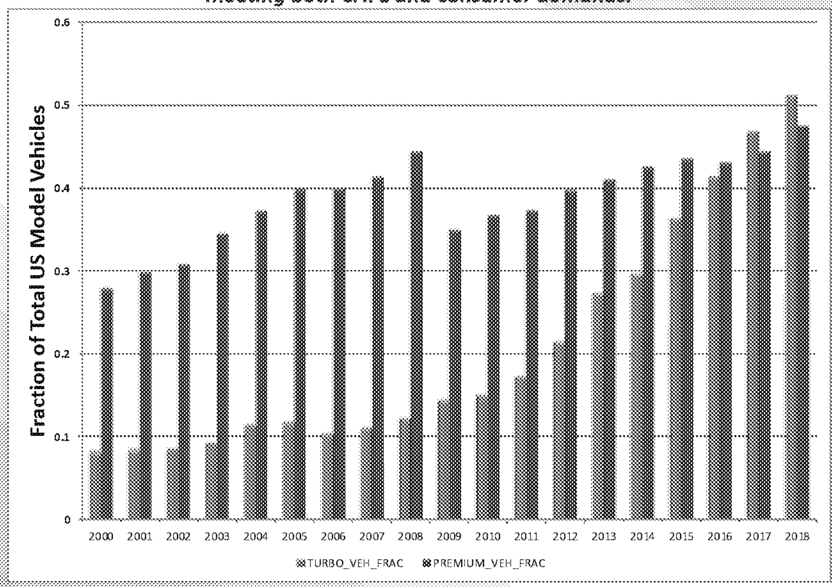
Butane and ethanol are two less costly high-octane gasoline blending components that are used to increase the octane of gasoline. However, these components also raise the vapor pressure of the gasoline blend and thus are typically limited by the maximum Reid Vapor Pressure (RVP) of the final gasoline blend. The combination of increasing consumption in the CFR market as well as the potential for a lower maximum RVP specification in the summer months could make it difficult for refiners to produce enough premium gasoline without capital investment or sourcing supply from other supply hubs such as the Gulf Coast.

Figure OV-5

U.S. New Vehicle Trends

Turbo and Premium Gasoline Vehicles: 2000 through 2018

Over half of new vehicles for model year 2018 have higher compression turbo-charged engines which typically require higher octane premium gasoline. The number of turbo-charged models has been increasing rapidly as they offer a compromise of power and fuel economy and are better suited to meeting both CAFÉ and consumer demands.



Source: EAI, Inc. analysis and interpretation of data from EPA

Colorado gasoline consumption growth has led to increased dependency on supply from outside of the state leading to increased utilization of pipeline logistics systems. Gasoline consumption is expected to peak in 2018 and start to decline thereafter with increasing oil prices and as demographic changes and fleet economy improvements offset population and economic growth.

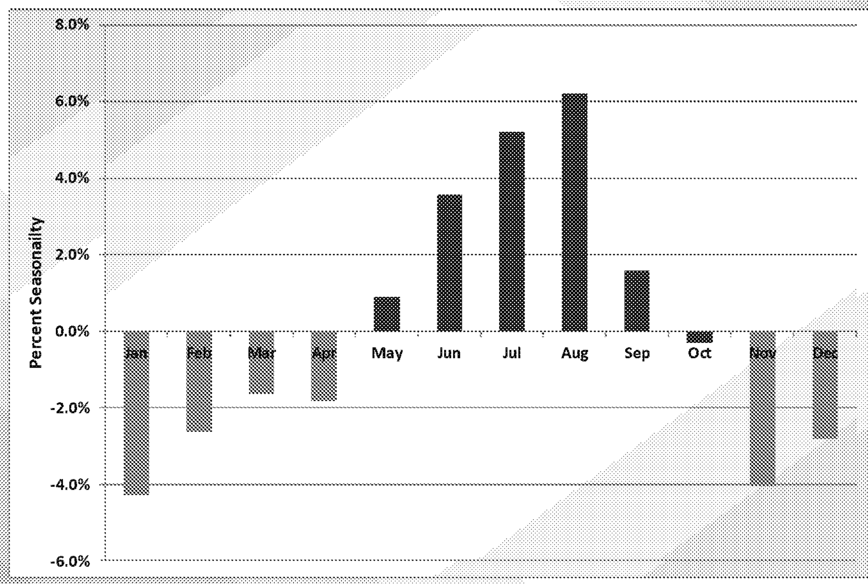
The seasonal nature of refined product consumption in Colorado means that pipeline logistical systems could be more constrained during certain times of the year than average annual flows would suggest as the state is ultimately dependent on incremental supply from outside of the state (which utilizes pipeline logistics for the most part).

Figure OV-6 shows the seasonality of refined product (gasoline, diesel, jet fuel) consumption since the year 2000. Colorado has relatively strong seasonal demand with refined product consumption typically peaking in the summer months coinciding with lower RVP gasoline requirements.

Figure OV-6

Seasonality of Colorado Refined Product Demand

Calculated as CO monthly refined product consumption for the past 17 years divided by the annual average refined product consumption minus 100%. The seasonality of consumption is input into how logistical system maximum and minimum utilization over the course of a year varies, a more accurate metric for determining total loadings. August consumption is about 6% greater than the average annual consumption while November consumption is about 4% less.



Source: EAI, Inc. analysis and interpretation of data from EIA and state departments of transportation

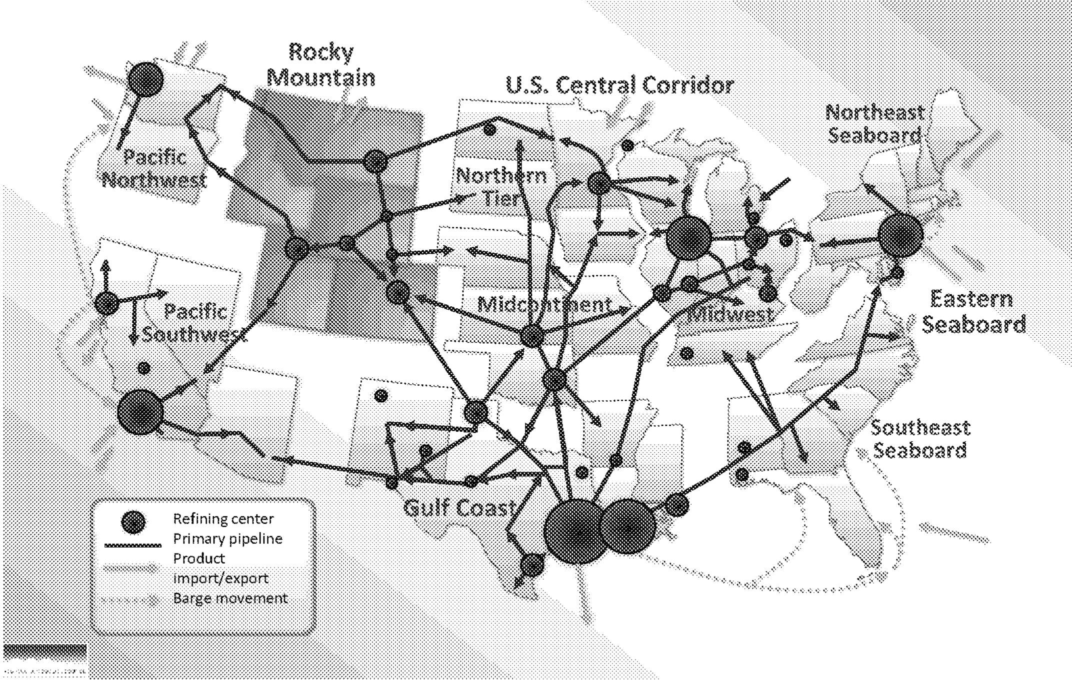
ROCKY MOUNTAIN AND CFR GASOLINE SUPPLY STRUCTURE

Colorado is part of the Rocky Mountain supply network region. As shown in **Figure OV-7** the region is relatively isolated in terms of multiplicity of supply sources compared to other regions of the country. This isolation takes a number of forms – limited number, capacity and capability of refineries that actually can supply the market, limited number and capacity of product pipelines that supply the market, and differences in gasoline product supply specifications for the CFR market versus outlying markets. It is possible for refined products sourced in the Gulf Coast (GC, Houston-Beaumont- Port Arthur area) to be transported via pipeline to the CFR market but this is generally not the case as supply can be provided by more closely located refineries. However, if needed and if pipeline capacity is available, this can be accomplished via shipping on Explorer or Magellan pipelines to the Tulsa, OK area, then on Magellan pipeline from Tulsa to Wichita – El Dorado, KS and then on Magellan-Chase pipeline from El Dorado to Aurora, CO. However, Magellan Midstream Partners would have to make capital investments in tankage for their pipeline system in order to accommodate Gulf Coast to Denver movements of low RVP gasoline.

Figure OV-7

U.S. Refined Product Network

Definition of EAI, Inc. U.S. Product Distribution Hubs and Regions. The Rocky Mountain refined products market is one of the more isolated regions.



Historically, shipments of product from the GC – Midcontinent (MC) to Colorado have been predominantly limited to jet fuel due to the pipeline bottlenecks or because the existing sources have been able to supply the required gasoline and distillate products. Also, as mentioned previously, low RVP gasoline cannot logistically move from the Gulf Coast to Denver via pipeline due to tankage constraints in the Magellan pipeline system. As a generality, the CFR and the Rocky Mountain region market use lower octane gasoline than outside markets due to the higher altitude, i.e. supplying Gulf Coast or Midcontinent grade gasoline would result in octane giveaway. Suppliers generally get around this problem by exchanging Gulf Coast or Midcontinent grade gasoline for CFR grade gasoline with Midcontinent refineries which have access to the Magellan-Chase pipeline into Denver.

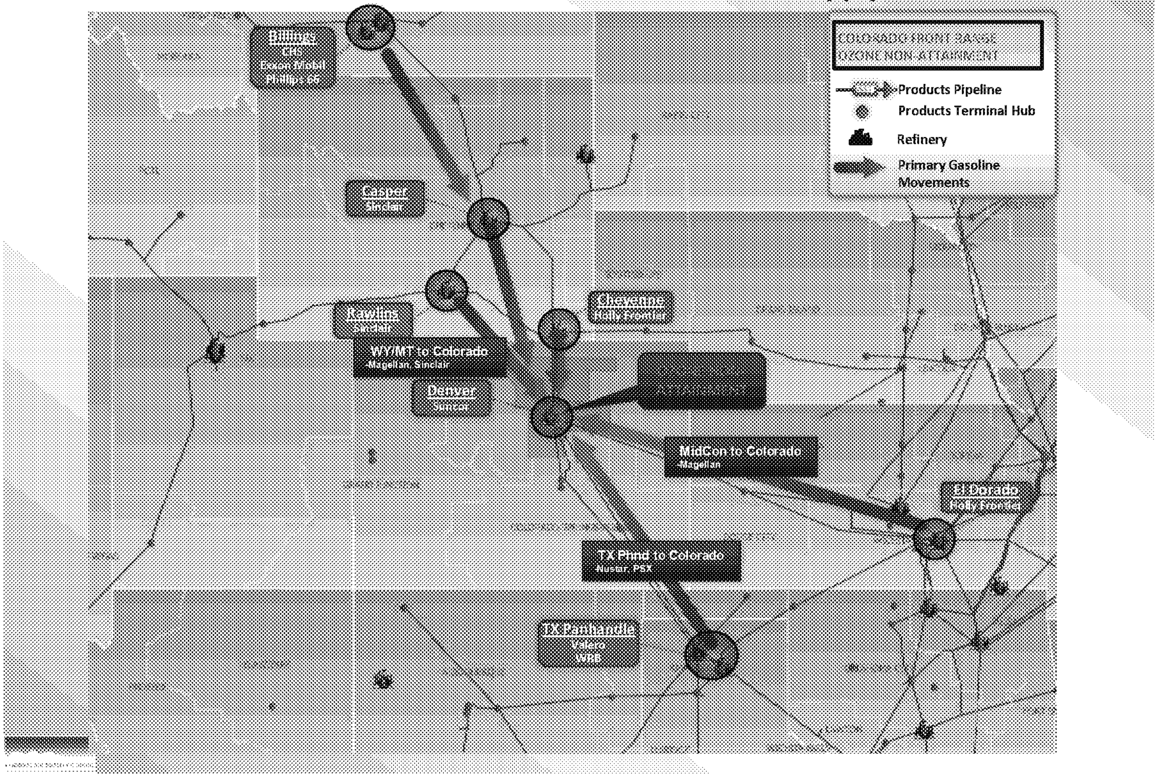
The CFR market is predominantly supplied by six refineries – one in state (Suncor) and five out-of-state (WRB Borger, HollyFrontier El Dorado, HollyFrontier Cheyenne, Sinclair Rawlins and

Valero McKee) which supply the Front Range via five refined product pipelines. Secondary sources of supply to the CFR market originate at other refineries in Billings, MT, Casper, WY, and the Midcontinent region. These refineries and product pipelines are shown in **Figure OV-8**.

Figure OV-8

EAI, Inc. Market Boundaries and Local Supply Network

Denver Ozone Nonattainment Market Area and Supply Sources



With the exception of small truck movements of gasoline into the state from surrounding states, almost all of the gasoline supplied to the Colorado market is delivered to the CFR product terminals via pipeline and distributed from there to outlying areas. Ethanol supply for the CFR market is trucked or railed into the Denver and Colorado Springs area terminals and then blended into gasoline product.

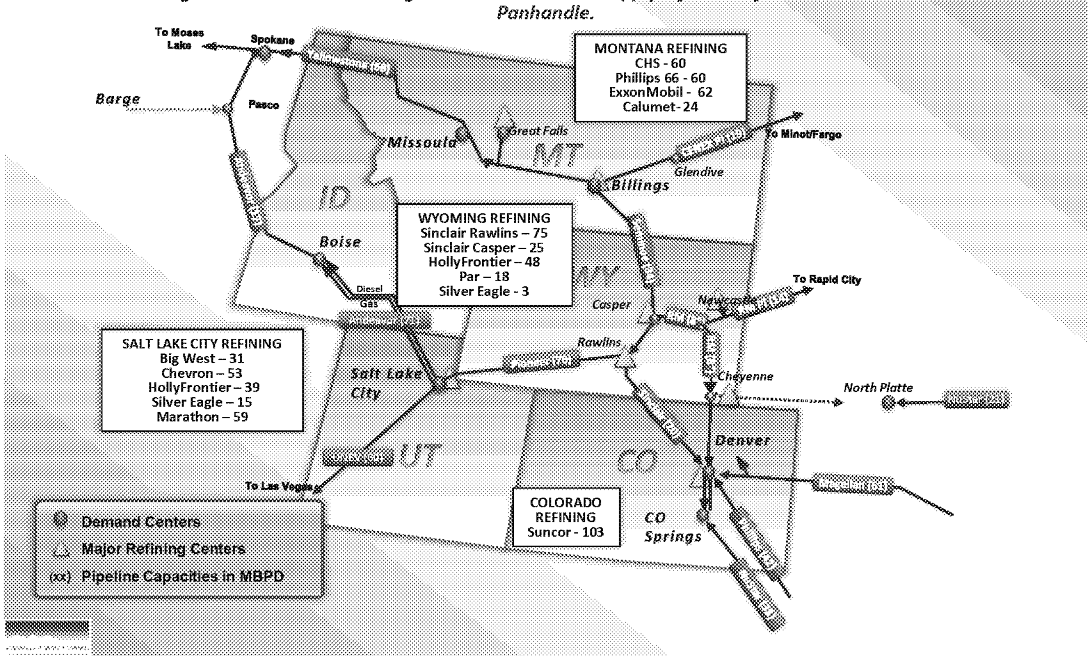
A more detailed view of the refined product supply network for the Rocky Mountains and the CFR Range is shown in **Figure OV-9**. The Suncor refinery in Commerce City, CO is the only refinery directly located in the CFR market. The Valero and WRB (Cenovus-Phillips 66) refineries supply the market via the 33 MBPD capacity NuStar and 42 MBPD capacity Phillips 66/Nustar product pipelines The HollyFrontier refinery in El Dorado, KS supplies the market via the 55 MBPD capacity Magellan-Chase pipeline. The HollyFrontier refinery in Cheyenne, WY supplies the market via the 25 MBPD capacity Magellan Mountain pipeline. Lastly, the Sinclair refinery at Rawlins, WY supplies the market via its Denver product pipeline which has an estimated capacity of 20 MBPD.

Figure OV-9

Refined Product Supply Network

Rocky Mountain Region

Rocky Mountain region is supplied by major refining centers in Colorado, Montana, Utah and Wyoming and a relatively simple network of product pipelines. Primary product export markets are to the West – Las Vegas and Eastern Washington. Colorado Front Range market has outside supply influences from the Midcontinent and Texas Panhandle.



The Sinclair Little America refinery in Casper, WY and the three Billings area refineries (CHS, Phillips 66, ExxonMobil) do supply product to the CFR market via pipeline, but in the recent past relatively little of this supply interaction has taken place. This is due to pipeline logistical limitations as well as tightness of product supply (and associated higher value) in the other Rocky Mountain markets north of Colorado.

The significant increase in gasoline consumption in the CFR between 2011 and 2017 has necessitated an increase of gasoline and ethanol supply from outside of the market as the local Suncor refinery has maintained relatively flat production having been fully utilized the majority of the time. **Figure OV-10** below shows the change in supply between 2011 and 2017 from each of the major supplier groups outside of the CFR market. The capacities and utilization rates of refineries supplying the CFR market have generally increased as well.

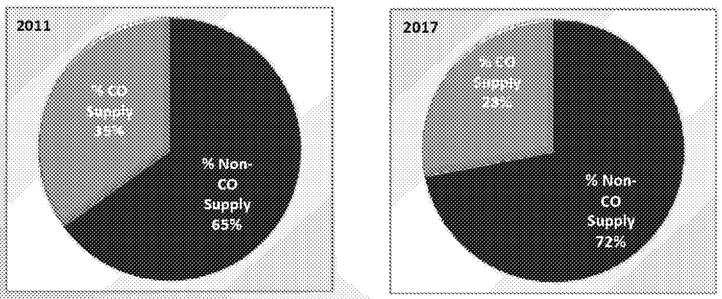
With the exception of the MC suppliers and the local Suncor refinery, each supplier group significantly increased gasoline deliveries into the CFR market. The MC refiners tend to be the swing/incremental supply into the CFR market depending on prevailing economics and typically have more market optionality than other major CFR suppliers.

Non-Colorado supply accounted for 72% of the total CFR supply in 2017 compared with 65% in 2011. An increase in non-CFR local supply means there are more external suppliers with a greater dependency on the CFR market for placing production, and thus more widespread impacts from a potential change in gasoline specifications. In addition, as supply has increased from outside of the CFR the respective logistical systems facilitating these movements have become more highly utilized on average. Ethanol has to be railed and/or trucked into the market as it cannot be transported on pipelines. A combination of increased Renewable Fuel Standards (RFS) as well as increased gasoline consumption overall has increased ethanol supply into the CFR market.

Figure OV-10

Gasoline Supply Change To the Colorado Front Range Market

Colorado Front Range Gasoline Supply Change, MBPD (2011 vs. 2017)					
Region	*Supplier*	*Product*	*2011*	*2017*	*Delta*
WY_MT	HollyFrontier, Sinclair, Phillips 66, Other	GASO	27	36	9
ETOH	(Ethanol) Various	GASO	8	15	7
TX_PHNDL	WRB, Valero	GASO	34	40	6
CFR	Suncor	GASO	43	42	-1
MC_GC	HollyFrontier, Other	GASO	11	17	6

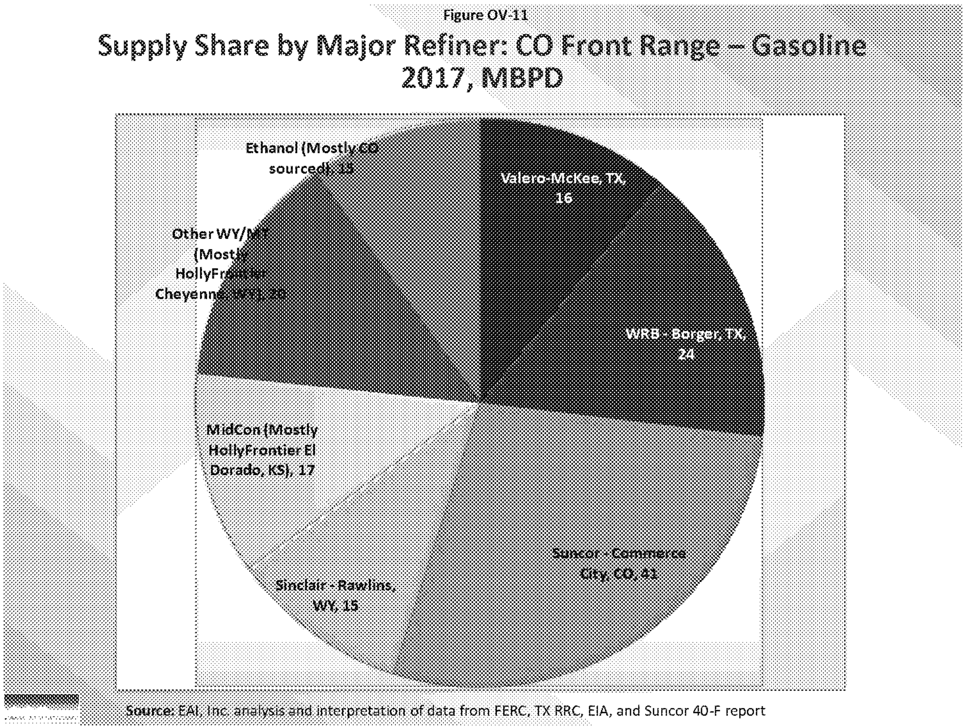


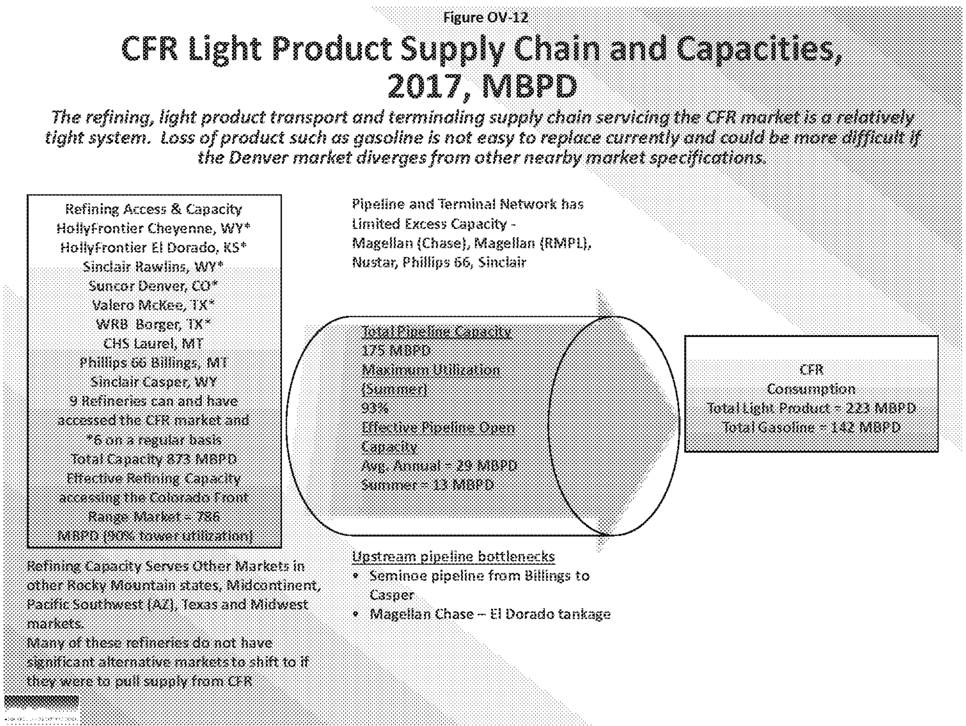
Source: EAI, Inc. analysis and interpretation of data from FERC, TX RRC, EIA, and Suncor 40-F report

The Suncor refinery is the largest source of supply to the Colorado market and two refineries, HollyFrontier Cheyenne and Sinclair Rawlins, place a large portion (> 33%) of their gasoline product into the CFR market. The other refineries supply a smaller fraction of their total gasoline production to Colorado, i.e. produce significant volumes of gasoline and supply these volumes to other markets. **Figure OV-11** shows the approximate CFR gasoline supply share by refiner.

The status of the combined portions of the product supply network for Colorado is summarized in **Figure OV-12**. Those refiners with the highest market share position and least alternative market options will have the greatest probability to produce gasoline to satisfy the Denver Front Range ozone fuel specification based on EAI, Inc.'s independent assessment.

This would include the Suncor-Commerce City and HollyFrontier-Cheyenne refineries which have the highest market shares and the least alternative markets options. Together they represent nearly 50 percent of the market plus additional share to account for the ethanol they use in the market.





Refiners outside of the CFR accessing product pipelines servicing the CFR figure prominently into the CFR gasoline supply. Besides gasoline, these pipelines also transport about 63% of the distillate and jet fuels consumed in the CFR market. Total capacity of the product pipelines into Colorado is 175 MBPD and on an annual average basis 29 MBPD of open capacity existed in

2017. Given the seasonality of refined product in consumption shown in **Figure OV-6**, peak utilization rates of the pipeline systems feeding the CFR market from out-of-state supply sources can be estimated.

Figure OV-13 below shows the estimated 2017 pipeline capacity (MBPD), total loading (MBPD – gasoline, diesel, jet fuel), 2017 peak seasonal loading (MBPD), and pipeline peak utilization rate for the pipelines suppling the CFR market from the three major non-CFR supply sources (Wyoming – Montana, Texas Panhandle, MC-GC). All of the major pipeline systems feeding Colorado from out-of-state supply sources are nearly fully utilized in the peak demand months of summer. Magellan recently put their Chase system from the MC on allocation. Greater volumes of diesel and jet fuel relative to gasoline tend to decrease the effective capacity of a pipeline. Diesel and jet fuel movements on the Magellan pipeline from the MC have been increasing relative to gasoline and therefore the effective capacity may have decreased from what is shown in **Figure OV-13**. In addition, the Magellan pipeline tends to see more seasonal variation in movements compared to the other pipelines as MCand GC supply are generally the incremental supply for the CFR market and thus likely has higher peak utilization levels. Given the six primary refineries supplying the CFR have been running fairly flat-out, the MC and GC would be the likely incremental supply if there were a supply upset, but given the current allocation (meaning the pipeline is at capacity) on the Magellan Chase pipeline and the Gulf Coast to Denver tankage constraints, Magellan would need to make capital investments to accommodate such movements.

Figure OV-13

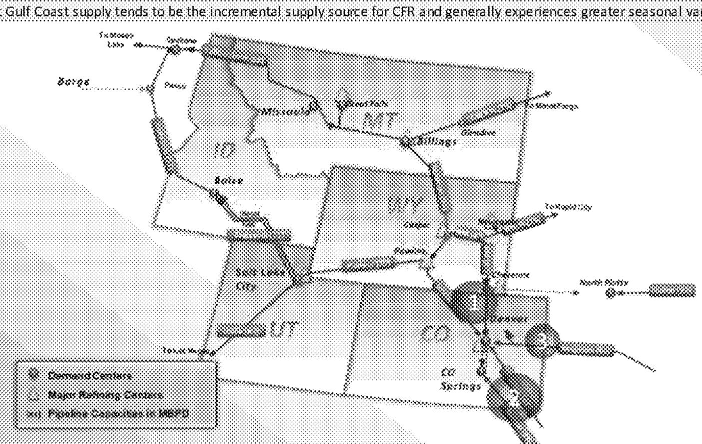
Refined Product Supply Network

CFR Pipeline Utilization

Colorado Front Range Pipeline Utilization (MBPD)

Source Region	Supplier	Pipeline(s)	Pipeline Capacity	2017 Total Loading	2017 Peak Seasonal Loading	Pipeline Peak Utilization
1) WY_MT	HollyFrontier, Sinclair, Phillips 66, Other	Magellan (RMPL), Sinclair	45	45	45	100%
2) TX_PHNDL	WRB, Valero	Nustar, Nustar/Phillips 66	75	61	71	94%
3) MC_GC*	HollyFrontier, Other	Magellan (Chase)*	55	40	46	84%
ALL	ALL	ALL	175	146	162	92%

Midcontinent Gulf Coast supply tends to be the incremental supply source for CFR and generally experiences greater seasonal variation



Source: EAI, Inc. analysis and interpretation of data from FERC, TX RRC, EIA, and Suncor 40-F report

REF

REFINING and COST IMPACTS

INTRODUCTION

In this section, the primary refineries supplying the Colorado Front Range area (CFR) are more fully described in terms of their individual capabilities, makeup and characteristics. The secondary refineries that have access to the CFR market area are also addressed and profiled but in less detail. Each primary supply refinery is reviewed to give a description of unit operations, the crude slates they are set up to utilize, and estimated outputs of refined products. As background, the primary refinery units and processes are described.

There are six primary supply refineries that service the bulk of the CFR market as well as four secondary supply refineries. These refineries and their respective locations are listed below:

SUPPLY	REFINERY	LOCATION
Primary	Suncor	Commerce City, CO
Primary	HollyFrontier	El Dorado, KS
Primary	HollyFrontier	Cheyenne, WY
Primary	Sinclair	Rawlins (Sinclair), WY
Primary	WRB	Borger, TX
Primary	Valero	McKee (Sunray), TX
Secondary	CHS	Laurel, MT
Secondary	Exxon Mobil	Billings, MT
Secondary	Phillips 66	Billings, MT

EAI, Inc. procured information addressing refinery and supply impacts as well as implications for impacts on fuel supply costs for all refining companies that play a significant role in supplying gasoline to the CFR market with specific focus on the DM/NFR NAA. The Refiner Survey, defined previously in this document, and information provided by each refiner for each of the relevant refineries was screened, interpreted and analyzed to evaluate the collective impact on industry costs and supply as well as the potential impact on consumer fuel costs for each of the fuel options being considered by the RAQC to comply with federal ozone air quality standards. Five companies representing eight refineries responded to the RAQC/EAI, Inc. formal survey:

- HollyFrontier: Cheyenne, WY and El Dorado, KS plants
- Phillip 66: Billings, MT and Borger, TX plants
- Sinclair: Casper, WY and Rawlins, WY plants
- Suncor: Commerce City, CO plant
- Valero: McKee, TX plant

There are several other plants that can and do access the DM/NFR NAA market area (in Billings, MT and the Midcontinent region) that did not respond to this survey. The refinery respondents represent at least 93.7 % of the gasoline supplied to the DM/NFR NAA market area. One significant difference for this 2018 impact study versus the 2011 study is that refiners have already made modifications/adjustments to supply the DM/NFR NAA with 7.8 pound RVP gasoline with a one pound ethanol waiver. Production of this environmental grade has likely already required removal of some butanes with replacement of lost octane value with other gasoline blend components during the DM/NFR NAA season. There are two scenario categories representing different levels of refinery/logistics investment capital intensity that are addressed in the summary of supply and cost impacts. It should be noted that not all refiner respondents had multiple capital intensity scenarios but those that did are represented in the response and cost impact results. The cost and supply impact results are summarized in the text below along with the metrics illustrated in the associated tables and graphics.

MAJOR REFINERIES SUPPLYING THE COLORADO/FRONT RANGE MARKETS

Overview of the Colorado Front Range Refinery Supply Network

Among the 10 refineries that supply the CFR market, there are two refineries that place most of their refined product output in the CFR market: 1) The Suncor Commerce City, CO refinery and 2) the HollyFrontier Cheyenne refinery. All of the other refineries distribute a significant fraction of their refinery output to markets other than the CFR market and some of them have limits in how much of their output can be placed in the CFR market due to transportation constraints. However, this network of refining options does have some flexibility in replacing lost production in the CFR market due to refinery or pipeline upsets that can and do occur. It should be noted that the CFR market has a lower octane requirement then most of the surrounding markets and some of the secondary supply refiners do not have storage capacity to segregate the lower octane material as a separate product. They can ship higher octane material to Colorado but would generally not want to give up octane value unless the combination of higher octane costs is supported by higher market value realization.

As stated above, there are six primary supply refineries serving the CFR market. Five of these primary supply facilities are located out-of-state, with one, the Suncor Commerce City, CO refinery located in-state. All supply significant portions of their output to the CFR market. **Figure REF-1** and **Figure REF-2** below show the estimated refined product geographical market orbits of these refineries

Figure REF-1

U.S. Western Region
(Cheyenne-CMRC City-Rawlins) Primary Product Distribution Boundaries

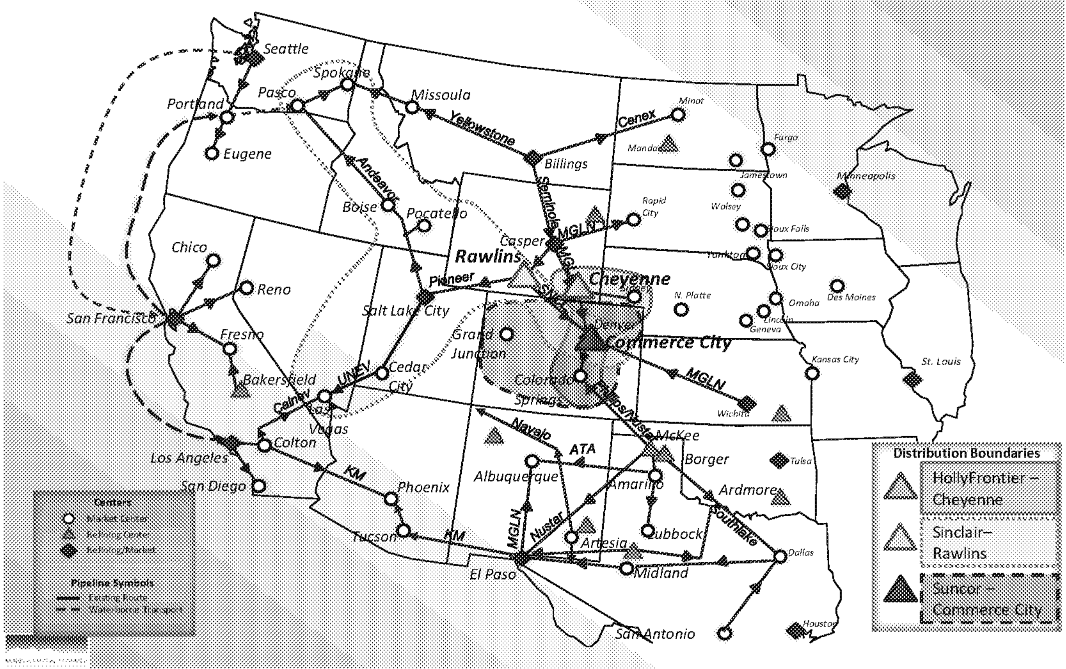
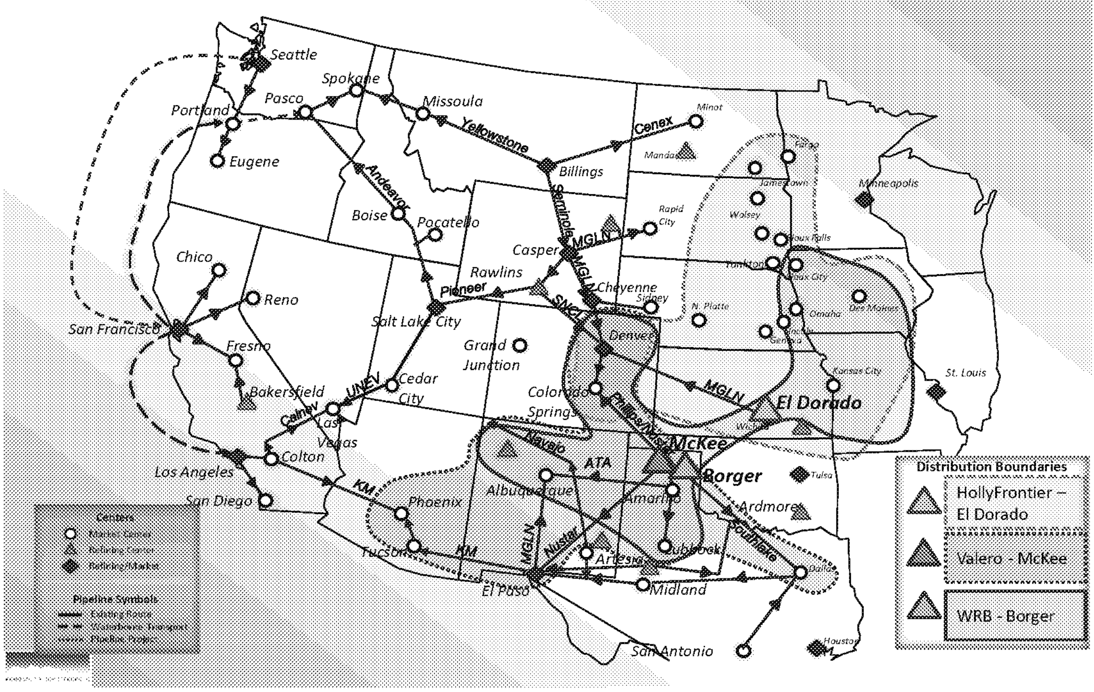


Figure REF-2

U.S. Western Region
(Borger-El Dorado-McKee) Primary Product Distribution Boundaries



A short discussion on refinery capabilities and markets supplied is provided below.

Suncor Commerce City Refinery

Overview and Configuration

The Suncor Commerce City Refinery is a 103 MBPD crude tower capacity refinery that is the result of combining the original ConocoPhillips 62 MBPD refinery with the Valero 27 MBPD refinery and expanding their combined capacity. Downstream processing units consist of vacuum distillation, FCC, reforming, polymerization, and asphalt. The Suncor refinery does not have an alkylation unit and uses polymerization units for production of cat poly gasoline via polymerization.

Refinery Production Distribution

Being located in the Denver area, substantially all of Suncor's refinery production is supplied to the CFR market. This includes the local Greater Denver metropolitan area, Colorado Springs via Magellan pipeline, and Grand Junction via rail. The Suncor refinery has pipeline connections to the NuStar Commerce City terminal, Phillips 66 Commerce City terminal, Magellan Dupont and Aurora terminals, and to the Magellan pipeline terminating in Fountain, CO near Colorado Springs.

Refinery Crude Supply and Slate

The crude slate for the Suncor refinery consists of a variety of crudes ranging from light Denver-Julesburg (DJ) Basin crude, Wyoming sweet and sour, Wyoming asphaltic, Canadian synthetic and Canadian medium and heavy crudes. Suncor processes a significant amount of lighter crudes such as those available from the DJ Basin which naturally have higher yields of components having higher RVP levels. This tends to increase production of light ends which makes it more difficult to meet reduced RVP gasoline specifications without incurring higher capital costs or a combination of lost product values and higher stream replacement costs. The supply of DJ Basin and other light crudes has been growing in recent years. This growth has tended to benefit Suncor and other refiners in the area that can access this crude or other crudes of similar type and cost. Reductions in running these lighter grades and replacing with higher cost alternatives would result in lost value and profit for these plants and likely increasing costs for wholesale product supplied to the market.

HollyFrontier Cheyenne Refinery

Overview and Configuration

The 48 MBPD (atmospheric crude tower capacity) HollyFrontier Cheyenne refinery represents the smallest of the CFR primary supply refineries. Downstream processing units consist of vacuum tower distillation, coking, FCC, reforming, hydrotreating, and alkylation.

Refinery Production Distribution

The HollyFrontier Cheyenne refinery's primary market areas include the local Cheyenne/Southern Wyoming market, Western Nebraska, and the CFR. HollyFrontier's largest market is the CFR and its supply reaches this market via truck and the 8", 25 MBPD capacity Magellan product pipeline (formerly part of the RMPL system) moving supply from Cheyenne to the Denver (DuPont) and Colorado Springs (Fountain) markets. As stated previously, The Cheyenne refinery likely has the least alternative market options than any of the other primary CFR refinery sources.

Refinery Crude Supply and Slate

Historically, the crude slate for the refinery consisted of heavy Canadian crude (such as Western Canadian Select) and a smaller amount of local light crudes. The refinery has historically shifted between a lighter and heavier crude slate based on the prevailing crude price differentials. More recently, HollyFrontier has tended to maximize heavy crude runs at the refinery as a result of favorable heavy crude to light crude discounts.

Sinclair Rawlins Refinery

Overview and Configuration

The Sinclair Rawlins refinery is a 75 MBPD crude tower capacity refinery and represents the next smallest of the primary CFR supply refineries. Downstream processing units consist of vacuum tower, asphalt, coking, FCC, hydrocracking, reforming, and alkylation.

Refinery Production Distribution

Product from the Sinclair refinery can access the CFR market via its own 6'' diameter, 20 MBPD (est.) capacity Denver Products pipeline. The refinery also has access to Salt Lake City – Idaho – E. WA markets via the Pioneer and Andeavor product pipelines and to Las Vegas via the 60 MBPD UNEV pipeline originating in Salt Lake City. Sinclair places a relatively large amount of its refinery production into the CFR market, but can optimize between placing supply there and alternative markets such as Salt Lake City, Boise/Pocatello, and Las Vegas. The refinery produces 7.8 psi gasoline for both the Denver and Salt Lake City markets during the summer.

Refinery Crude Supply and Slate

The crude slate for the Sinclair refinery consists of heavy Canadian crude, heavy Wyoming crude, Canadian synthetic and local light crudes and optimizes this slate based on the prevailing light-heavy crude differentials and a number of other considerations.

HollyFrontier El Dorado Refinery

Overview and Configuration

The Frontier El Dorado refinery is a 160 MBPD crude tower capacity refinery and represents the largest source of Midcontinent supply to the CFR market. Downstream processing units consist of vacuum tower, FCC, reforming, alkylation, coking and isomerization units.

Refinery Production Distribution

The HollyFrontier El Dorado refinery is the primary supply refinery for the Magellan-Chase product pipeline moving to the Denver area terminals. The refinery has access to a wide variety of Midcontinent and Northern Tier markets via connections to Magellan, NuStar and Heartland pipeline systems. Besides making summertime 7.8 RVP gasoline for Denver, the HollyFrontier El Dorado also produces 7.0 RVP summertime gasoline for the Kansas City market.

Refinery Crude Supply and Slate

The HollyFrontier El Dorado refinery has access to numerous sources of crude from the Midcontinent, West Texas, Gulf Coast, the Rockies and Canada with direct pipeline access to the Cushing, OK crude logistics and trading hub.

WRB Borger Refinery

Overview and Configuration

The WRB Borger refinery is a 146 MBPD crude tower capacity refinery with downstream processing units consisting of a vacuum tower and FCC, reforming, coking, isomerization, and alkylation downstream units. The refinery is jointly owned by Phillips 66 and Cenovus Energy and operated by Phillips 66.

Refinery Production Distribution

The WRB refinery ships product to the CFR market via the Phillips 66 product pipeline from Borger to La Junta and Commerce City, CO. The WRB Borger refinery places a significant portion of its production into the CFR market, but also places product in a number of Midcontinent markets (Wichita, Kansas City, etc.), Amarillo/Lubbock, TX, and Albuquerque, NM. The refinery produces low RVP gasoline such as 7.8 psi for the Denver market and 7.0 psi for the Kansas City market.

Refinery Crude Supply and Slate

The WRB Borger refinery processes primarily West Texas sour crude with smaller amounts of WTI, Oklahoma crudes and Canadian Heavy origin crudes. The refinery has fairly flexible crude selectivity being in close vicinity of the Cushing crude storage and trading hub as well as the

Permian Basin.

Valero McKee Refinery

Overview and Configuration

The Valero McKee refinery is a 195 MBPD crude tower capacity refinery and represents the largest of the CFR supply refineries. Downstream processing units consist of vacuum tower, asphalt, FCC, hydrocracking, reforming, isomerization, and alkylation.

Refinery Production Distribution

The Valero Mckee refinery supplies the Colorado Springs and Denver markets via the Nustar and Phillips 66/Nustar pipelines originating near the refinery. The refinery places a large portion of its total supply into the CFR market, but also has product pipeline access to markets in West Texas (El Paso), New Mexico (Albuquerque), Arizona (Tucson, Phoenix), and Dallas. Besides making summertime 7.8 psi RVP gasoline for Denver, the Valero McKee refinery also produces Arizona CBG gasoline for the Phoenix market, 7.0 psi RVP gasoline for the El Paso market, and a small amount of reformulated gasoline blend-stock (RBOB) for the Dallas market.

Refinery Crude Supply and Slate

The Valero McKee refinery processes primarily West Texas Intermediate and other Permian Basin crudes with smaller amounts of WTS, Southeast Colorado, and Southwest Kansas origin crudes. With its proximity to Cushing and the Permian Basin as well as good pipeline connectivity, the refinery has some flexibility in crude supply.

REFINERY SUPPLY COST IMPACT

Overall Refinery Impacts: A principle finding of this study is that each of the options under consideration has its own cost and fuel supply impacts with the more stringent the fuel control scenario, the higher the gasoline production cost. These cost components include; refinery capital costs, cost of refinery operation, lost product value due to rejecting higher value streams to lower value end uses and increasing supply costs due to companies shifting their product out of the Front Range market to avoid investment. Gasoline supplies were also more impacted under the more severe fuel option scenarios. The most stringent gasoline specification scenarios are expected to achieve the largest air quality benefit and have the highest cost impacts on refinery operations and potentially consumer costs. One of the major values and inputs from this study is to evaluate the cost-benefit impacts of the various fuel options being considered versus other means of reducing CFR ozone levels to meet federal regulations. The gasoline specifications being evaluated for the DM/NFR NAA area will impact refiners in several ways depending on the fuel strategy option being considered and each refiner's plant configuration, operations and market options:

1) ***Refinery Hardware Investments***: In general, most of the refinery strategies for fuel and ozone compliance were related to rejection of higher RVP gasoline blend stocks such as butane and Light Straight Run (LSR) streams. This includes new or expansion of existing rail/tankage facilities to accommodate exports from the refinery facilities to markets external to the Rockies such as the U.S. Gulf Coast. With respect to significant refinery process hardware investments, the capital requirements for the Low Intensity Scenario 1, were mainly for recovery and removal of these light end components from in-plant refinery streams so they could be exported to other markets (generally the Gulf Coast) to avoid processing or blending them into the finished gasoline pool during the peak ozone nonattainment season. For the Higher Intensity Scenario 2, there were additional capital expenditures for processing the LSR stream to finished gasoline. This would could also involve recovery of LSR/pentanes plus but for converting these streams to finished gasoline and accommodating this with expansion of downstream units such as reforming which produces a relatively high value octane stream for blending. The LSR recovery and processing approaches occurred for the 7.8 psi No Waiver (NWVR) case and for the 7.0 psi With Waiver (WWVR) case but also resulted in the production of increasing amounts of 9 psi gasoline during the peak ozone season when this grade cannot be used in the DM/NFR NAA market area (see further discussion below on Gasoline Grade Selectivity).

2) ***Light Straight Run (LSR or Pentane Plus – C5/C6+) and Butane Rejection***: The removal and export of LSR and butane represents one of the most significant impacts on DM/NFR NAA supply and/or costs. In addition to the refinery modifications mentioned above to recover these streams from crude tower lighter end output, there are increased costs to export these streams to the Gulf Coast or other markets in addition to netback value realizations that are considerably less than those realized by processing these streams into finished product for more local markets. The removal of these streams, for some refinery cases, resulted in lower gasoline output for the DM/NFR NAA market. For other refinery cases, the butane and LSR components rejected and resultant products were replaced with other gasoline component blend stocks with lower RVP and comparable or higher octane levels. This is accomplished by importing additional iso-octane/alkylate to replace rejected component volume and octane but at significantly higher costs than converting the rejected streams to finished gasoline.

3) ***Reduction of Compliant Gasoline for the DM/NFR NAA Market***: There were several drivers for the reduction of compliant gasoline for the DM/NFR NAA market: a) refiners indicating they would not convert all of their current DM/NFR NAA gasoline to new compliant fuel specifications (due to refinery limitations and cost barriers) and would shift some or all of their current DM/NFR NAA 7.8 pound RVP gasoline with ethanol waiver (WWVR) supply to 9 pound RVP markets. This latter response was the dominant source of reduced DM/NFR NAA supply, b) refiners indicating they would not replace all of the rejected LSR / butane material with externally sourced streams to maintain their current level of gasoline output for the DM/NFR NAA market, and c) reductions of gasoline yield from processing units such as reformers that would be run at increased severity levels to increase the production of higher octane/lower RVP gasoline blendstocks to replace the loss of rejected streams or to replace ethanol for the "eliminate ethanol blending" case.

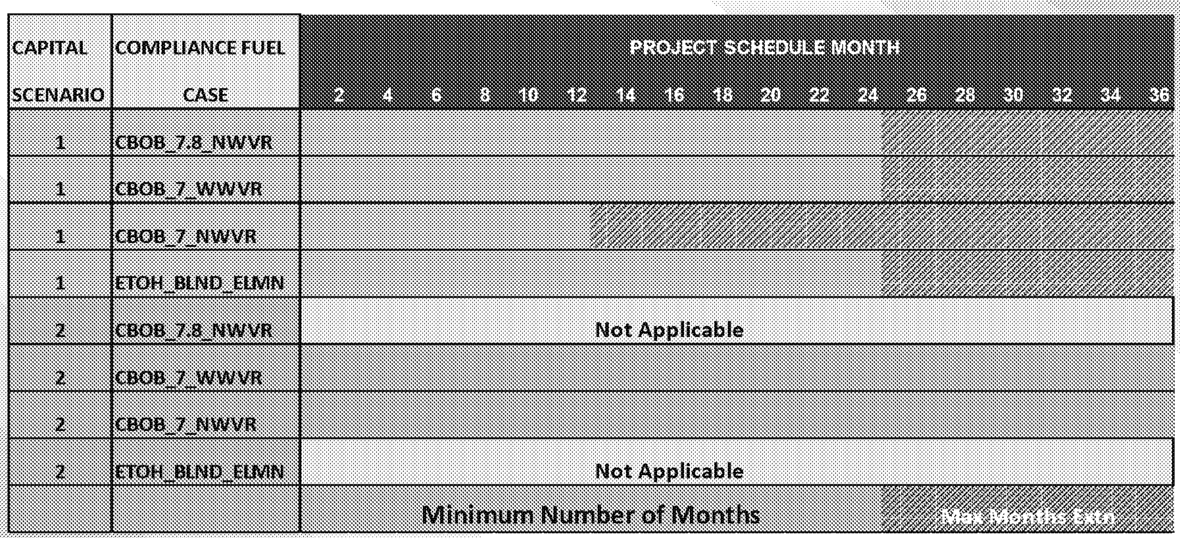
As indicated above, some of the fuel options being considered could negatively impact the availability of gasoline supply for the Greater Denver market area as well as increase production costs for DM/NFR NAA compliant gasoline relative to current gasoline production costs. The combination of increased production costs and higher probability for supply tightness and pricing upsets will increase prices realized by the commercial and private sectors in the DM/NFR NAA market area relative to other conventional gasoline markets that are open to un-obstructed incremental supply such as the Midcontinent. The larger refiners serving the Greater Denver NAA and having the most market options generally realize the least impact on both capital and operating costs. The refiners having a combination of limited alternative market options and/or smaller scale processing capabilities generally will experience the greatest cost impacts (combination of capital, operating and lost opportunity costs).

Tankage and Distribution Facility Investments: In addition to refinery units/hardware and operating changes, a common need associated with most of the new fuel specifications being considered was for expanded tankage and rail loading and unloading facilities to accommodate increasing LSR and butane exports as well as increases in iso-octane imports. This generally resulted in refineries specifying the need for such facilities to accommodate peak export or import levels that would occur during the peak ozone season extending from June through mid-September and ramp-up/ramp-down shoulder season periods (total estimated days per peak ozone season used was 160 based on refinery responses). These load levels could be in the order of 304 MBBLS or 10 MBPD. The current seasonal co-existence of 7.8 NWVR gasoline in the DM/NFR NAA area as well as 9.0 psi gasoline for peripheral markets can accommodate quite a bit of the shift to other LRVP gasoline grades with the caveat that there may have been more crossover of 7.8 psi gasoline WWVR into 9 psi markets due to a smaller gasoline grade cost differential than is likely for the new gasoline specifications being considered. This would result in less fuel supply-distribution flexibility than currently exists with refiners reluctant to substitute 7.8 WWVR, 7.0 WWVR and 7.0 NWVR with 9 psi gasoline due to the higher cost differential. This situation could also impact the longer haul pipelines such as P66, Nustar and Magellan (from Wyoming and Kansas) since some of them may be moving 7.8 WWVR to supply both 7.8 and 9 pound gasoline markets (EAI, Inc. had not verified this for all pipelines at the time of this writing).

Implementation Schedules: Depending on the fuel option being considered and the company/facility and capital requirements, the schedule for implementation can range from minimal time requirements to 72 months. Based on the refiner survey responses, some companies opted for lower capital cost solutions involving a combination of retracting gasoline from the NAA and shifting supply to alternative (less stringent gasoline markets) as well as rejecting some light stream gasoline blend stocks and shifting these to lower value markets. However, collectively this is probably not a realistic response longer term given the supply disruption and market price increases that would potentially result. It is more likely that refiners would make larger investments to comply with the proposed fuel options and place more gasoline in the NAA market which would also help mitigate supply disruptions and significant price increases to the NAA. This more realistic refiner response to the more stringent fuel options would require not only larger capital investments but also a longer schedule for implementation which could extend as long as 72 months for completion. Depending upon the fuel specification change, the refiners indicated the need for adequate time to implement capital investments and would require support from the state to ensure permitting and other requirements. To implement these more extensive modifications, there could be significant down time and other refinery impacts, which could also impact supply. The schedule shown in **Figure REF-3** below is to cover the shortest schedule indicated and the maximum schedule indicated for a given fuel case and capital scenario (and not accounting for higher capital based projects and associated schedules as addressed above). As shown, the Lower Capital Intensity projects require at least 24 months with a maximum schedule indicated of 36 months except for the 7 pound NWVR case which indicated a minimum schedule requirement of 12 months. This schedule was associated with one refiner for constructing tanks to accommodate LSR exports and iso-octane blending. The higher capital scenarios were applicable for only two gasoline specification cases shown below and both required at least 36 months for completion. However, significant refinery changes in blend stock sourcing or implementing a new market outlet for finished products or intermediates would still take significant time to implement; more on the order of several months to attain a steady state market position (for acquiring and receiving iso-octane from the Gulf Coast or shipping Light Straight Run material from inland areas to the Gulf Coast market for example).

Figure REF-3

Compliance Fuel Project Schedules
Refineries Supplying Denver Front Range Non-Attainment (NATN)
Project Schedules to Accommodate Facility Modifications and New Builds
Min to Max Number of Months for Completion



Other Potential Federal Fuel Changes and Integration: Refiners stressed the need for government transparency, decisiveness, and clarity regarding other potential federal regulations impacting fuel specifications such as the 95 minimum octane gasoline requirement, the Renewable Fuel Standard, and new changes to atmospheric ozone limits that would allow them to plan a cohesive response strategy that takes all of the relevant regulations into account. Ultimately, this would lead to more streamlined and cost-effective response strategies.

Basis for Total Incremental Production/Supply Costs: EAI, Inc. approached its assessment of ozone compliance fuel option costs in two ways:

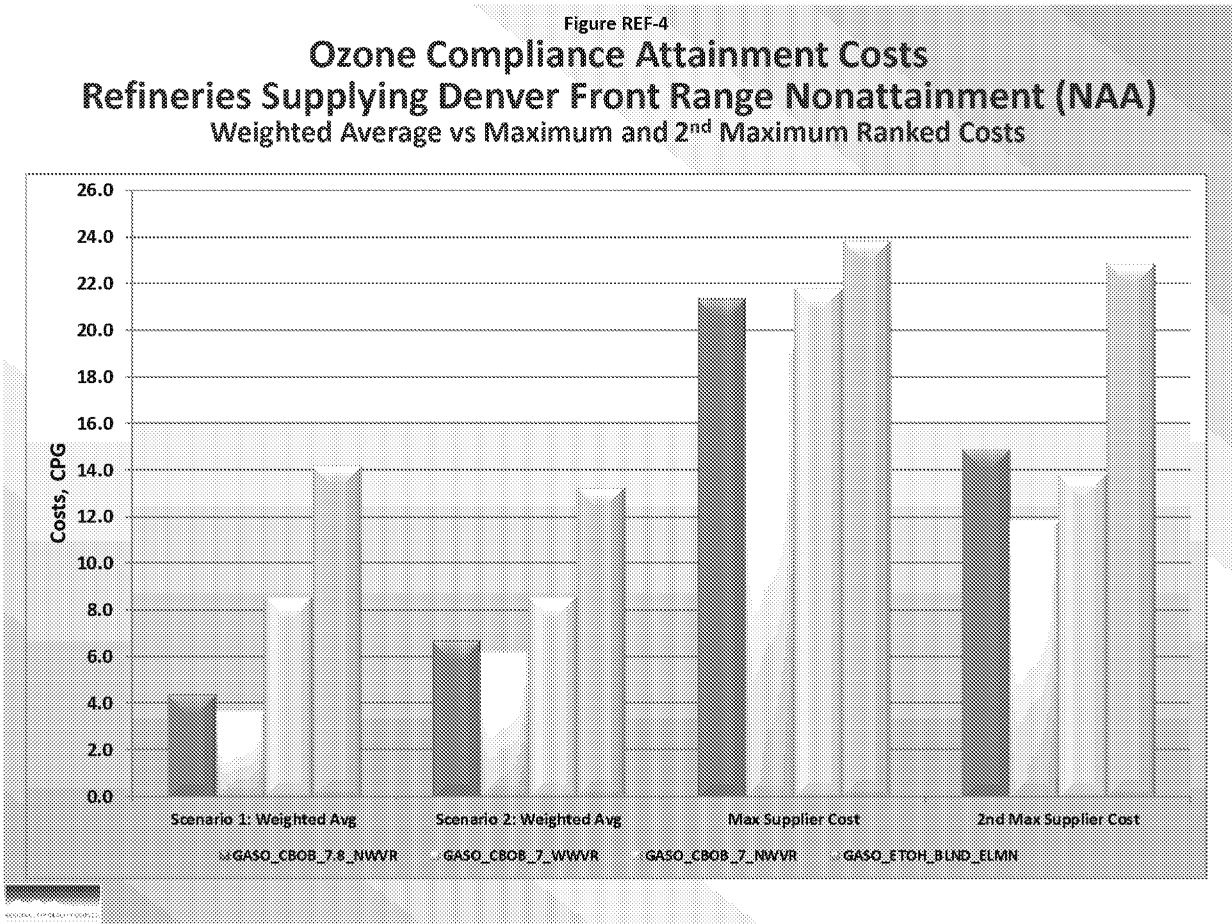
1) Weighted volume industry costs across all refinery-supplier combinations, all fuel options being considered and for the two capital intensity scenarios. The results of this analysis can be used to assess the total cost burden on industry to comply with the various fuel options being considered across all the cost impact categories (operating costs, capital costs and lost opportunity costs). The results of this analysis are presented in **Figure REF-4** through **Figure REF-6.**
2) Maximum and second ranked maximum costs based on a ranking of all refiner-supplier costs across the same cost categories indicated above. The results of this analysis can be used to assess incremental supply costs expected for the DM/NFR NAA market area for each of the fuel options being considered. Based on the survey results and EAI, Inc. analysis, it is very likely that the supply options for each of the fuel grades being considered will be limited and the highest cost source of required incremental supply required to satisfy CRF-NATN demand will set the clearing price for the market. These results, summarized in **Figure REF-4**, represent the potential impact on fuel costs that the DM/NFR NAA consumer/fuel purchaser will realize. In addition, the evaluated fuel options and respective clearing prices establishes the basis for the wholesale rack price that presents the price and revenue (when multiplied by sales volume) realized for each of the refiner-suppliers. The highest cost suppliers will realize the lowest margin realization and, depending on their investment requirements, potentially the lowest return on investment to comply with the considered new fuel option specifications.

The volume weighted program costs per gallon include estimates of incremental operating costs, incremental capital costs (distributed over 10 years) and lost value for shifting refinery light ends from a higher value gasoline market option to lower value butane or light straight run (LSR) markets. These costs represent incremental costs beyond current costs to manufacture 7.8 gasoline WWVR for the DM/NFR NAA. In addition, for some refiners and some of the cases, replacement gasoline blend streams will have to be purchased from sources generally external to the local Greater Denver market that represent higher costs than current gasoline supply components. It should also be noted that among the various refiner survey responses there were different approaches taken on what constituted operating costs vs opportunity costs for rejected LSR components and how lower netback values for finished gasoline shifted out of the DM/NFR NAA markets were handled and where the associated costs were lumped. It is more representative to assess the combination of operating costs and lost light stream value rather than focusing on the individual cost categories since there are differences among the refiners on where they were assigned and how they were defined and computed.

Comparison of Evaluated Fuel Option Costs: A comparison all fuel options costs is shown in **Figure REF-4** below with the following key observations and assessments.

- **Volume Weighted Industry Composites**: As shown for the Low Capital Intensity Scenarios and representative weighted cost roll-ups, the total average weighted incremental production costs range from 3.66 to 14.19 CPG with "eliminate ethanol blending" case being the highest cost fuel option. The 7.8 NWVR and 7.0 WWVR cases are close at 4.4 and 3.7 CPG respectively. The Higher Capital Intensity Scenarios result in an increase of the 7.8 NWVR and 7.0 WWVR cases to 6.69 and 6.17 CPG respectively.

- **Highest Incremental Refiner-Supplier Costs-Maximum and 2nd Maximum**: The maximum and 2nd maximum relative cost ranking of the fuel options being considered is the same as the volume weighted cost ranking as might be expected. What is important in these results is the representation of the highest cost suppliers:
  - The lowest cost option, 7.0 WWVR, is approximately 12.0 to 19.4 CPG representing 2nd Max to Max refinery-supplier incremental costs.
  - The differential between the next lowest cost options and the lowest cost option indicated above narrows relative to the weighted volume results to roughly 2.0 to 3.0 CPG for the Max Ranked Cost group.
  - The 2nd Max results indicate considerably lower refinery-supplier costs for all except the ethanol blending elimination case at roughly 7-8 CPG less.
  - EAI, Inc. believes the range of Max to 2nd Max refiner-supplier costs reasonably represents the incremental ozone compliant fuel costs relative to current 7.8 WWVR fuel costs and will be reflected at the wholesale rack and retail operations located in the DM/NFR NAA market area. There is some reason to believe that the Max cost refinery-supplier could withdraw from the market and be replaced by alternative supply sources that would represent lower cost options than the Max group costs.



The range of costs for the most realistic representation of refinery response is as follows (drawing on the Max and 2nd Max refiner-supplier costs shown in the Figure REF-above):

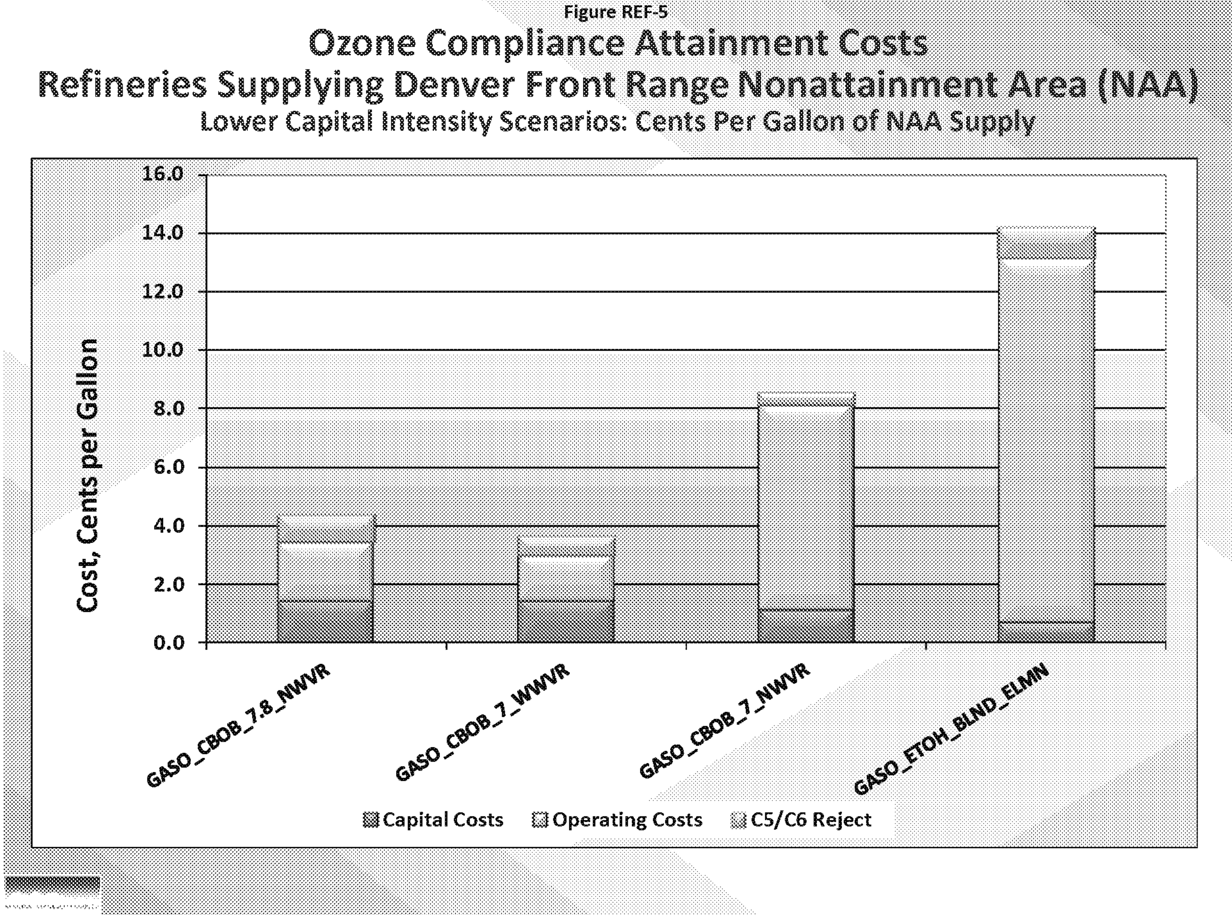
- *7.0 psi and 7.8 psi (with No Waiver)*: At 14.5 to 21.0 CPG, the 7.8 psi NWVR fuel option was very close to the 7 psi with the ethanol waiver (WWVR) case. The refinery survey inputs for the 7.0 psi NWVR case were limited as two of the respondent refiners indicated they would not be able to produce or supply the 7.0 psi NWVR gasoline and would have to do some combination of shifting 9.0 psi RVP gasoline to other markets and reducing refinery output of product that could not be placed.

- *7.0 psi with Waiver*: The costs representing the majority of the NAA gasoline volume was in the range of 11.8 to 19.0 plus CPG, which are less than the 7.8 psi NWVR and 7.0 psi NWVR cases. This includes a high of 2.0 CPG for incremental operating costs, 8.0 to 14.0 CPG for light-end rejection, and capital costs ranging from 0.7 to 2.2 CPG of output (based on amortizing capital costs over 10 years).

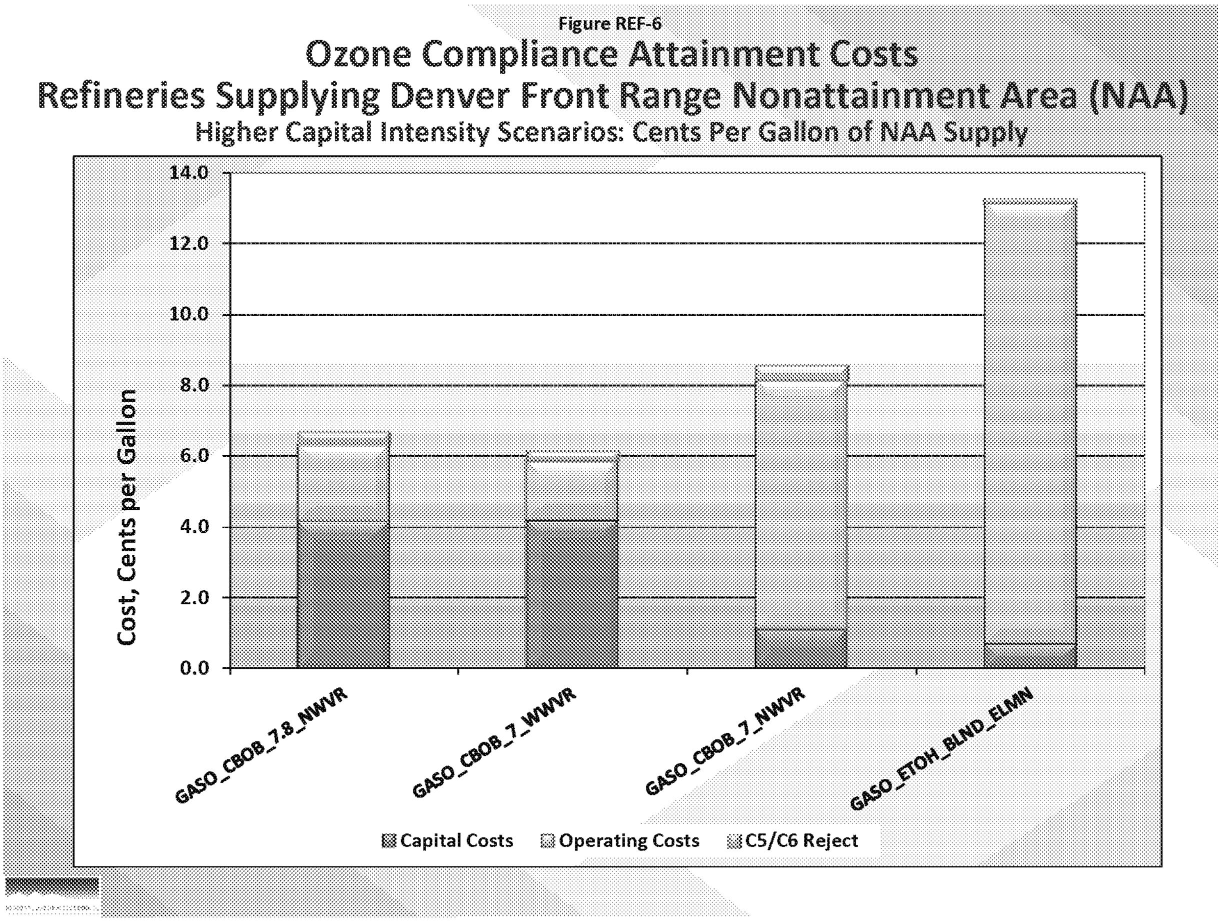
- *Eliminate Ethanol Blending*: This was the highest cost case in terms of capital expenditures, light end rejections and incremental operating costs with a range of 22.5 to 23.8 CPG for the Max and 2nd Max refinery-suppliers. It should be noted that RINs costs and purchase of iso-butane to offset the loss of ethanol blend component are likely significantly understated and the costs would be higher than indicated in the aforementioned figures.

Weighted Volume Costs Comparison of Compliant Fuel Option Costs: A summary of volume weighted refiner-supplier costs in response to the various fuel options being considered is summarized in **Figure REF-5** through **Figure REF-**7 below. The first chart illustrates comparative costs for the Lower Capital Cost Intensity Scenarios.

Figure REF-5



As shown, these volume weighed costs are significantly less than the Max and 2nd Max costs presented previously representing, to some extent, the relatively wide range of impact the different fuel options will have across the different refiners that supply the NAA market.



A more detailed summary of refining cost and supply impacts is shown in **Figure REF-7** below for all the cases considered and for both Capital Intensity Scenarios with some observations and insights for the various cost segments.

Figure REF-7

Ozone Nonattainment Fuel Cost (Weighted Avg.) and Supply Impacts

SCENARIO 1: LESS INTENSIVE CAPITAL EXPENDITURES

METRIC	STREAM	UNITS	SPLY 2017	CBOB_7.8_NWVR	CBOB_7_WWVR	CBOB_7_NWVR	ETOH_BLND_ELMN
COSTS	OPERATING COSTS	CPG		2.0	1.6	7.0	12.4
COSTS	CAPITAL COSTS	MM_$		57.0	57.0	25.0	25.5
COSTS	CAPITAL COSTS PER SUPPLIED GALLON	CPG		1.4	1.4	1.1	0.7
COSTS	BUTANE VALUE LOSS	CPG		0.1	0.0	0.3	0.0
COSTS	LIGHT STRAIGHT RUN (LSR) VALUE LOSS	CPG		0.9	0.6	0.1	1.0
COSTS	TOTAL BUTANE AND LSR VALUE LOSS	CPG		0.9	0.6	0.4	1.0
COSTS	TOTAL COSTS	CPG		4.4	3.7	8.6	14.2
OUTPUT	NATN SUPPLY	MBBLS	13638	13120	13157	7465	12067
OUTPUT	BUTANE REJECTION	MBBLS		205	168	264	71
OUTPUT	PENTANES PLUS REJECTION	MBBLS		912	742	175	971
OUTPUT	BUTANE AND PENTANES PLUS REJECTION	MBBLS		1117	910	439	1042
OUTPUT	LOST GASOLINE SUPPLY	MBBLS		819	668		915
OUTPUT	GASOLINE SHIFT TO OTHER MARKETS	MBBLS		16	11	1183	698
OUTPUT	GASOLINE SUPPLY LOSS (NATN)	MBBLS		835	679	5862	1613
SCHEDULE	MINIMUM PROJECT SCHEDULE DURATION	MONTHS		24	24	12	24
SCHEDULE	MAXIMUM PROJECT SCHEDULE DURATION	MONTHS		36	36	36	36

SCENARIO 2: MORE INTENSIVE CAPITAL EXPENDITURES

METRIC	STREAM	UNITS	SPLY 2017	CBOB_7.8_NWVR	CBOB_7_WWVR	CBOB_7_NWVR	ETOH_BLND_ELMN
COSTS	OPERATING COSTS	CPG		2.2	1.7	7.0	12.4
COSTS	CAPITAL COSTS	MM_$		152.0	152.0	25.0	25.5
COSTS	CAPITAL COSTS PER SUPPLIED GALLON	CPG		4.2	4.2	1.1	0.7
COSTS	BUTANE VALUE LOSS	CPG		0.1	0.0	0.3	0.0
COSTS	LIGHT STRAIGHT RUN (LSR) VALUE LOSS	CPG		0.3	0.2	0.1	0.1
COSTS	TOTAL BUTANE AND LSR VALUE LOSS	CPG		0.4	0.3	0.4	0.1
COSTS	TOTAL COSTS	CPG		6.7	6.2	8.6	13.3
OUTPUT	NATN SUPPLY	MBBLS	13638	12193	12136	7465	12067
OUTPUT	BUTANE REJECTION	MBBLS		207	179	264	71
OUTPUT	PENTANES PLUS REJECTION	MBBLS		303	226	175	971
OUTPUT	BUTANE AND PENTANES PLUS REJECTION	MBBLS		510	357	439	1042
OUTPUT	LOST GASOLINE SUPPLY	MBBLS		1745	1689	0	915
OUTPUT	GASOLINE SHIFT TO OTHER MARKETS	MBBLS		16	11	1183	698
OUTPUT	GASOLINE SUPPLY LOSS (NATN)	MBBLS		1761	1700	5862	1613
SCHEDULE	MINIMUM PROJECT SCHEDULE DURATION	MONTHS		36	36	36	24
SCHEDULE	MAXIMUM PROJECT SCHEDULE DURATION	MONTHS		36	36	36	36

The low RVP gasoline season lasts between May 1st and September 15th at bulk supply terminals

Capital Cost Impacts: Total industry capital costs to comply with the various gasoline grades being considered is in the range of $25 million for the CBOB 7 psi NWVR and "eliminate ethanol blending" cases to $57 million for the 7.8 NWVR and 7.0 WWVR cases for the Low Capital Intensity cases. The capital costs for industry in response to the fuel options being considered increases to $152 million for the High Capital Intensity scenarios and the 7.8 NWVR and 7.0 WWVR fuel options.

The capital costs for the Low Capital Intensity responses generally represent tankage and rail facilities to export increasing volumes of LSR and butane and import increasing volumes of iso-octane blend stocks. The higher capital costs indicated for the High Capital Intensity cases reflects refinery strategies to reduce exports of LSR material and increase refinery capabilities to process more of the LSR to finished gasoline product. However, the increased LSR processing is more directed to producing 9 psi gasoline and shifting it to conventional grade gasoline markets with the price realization risk less than realized by increasing LSR exports to a Gulf Coast market that is likely to deteriorate in value.

EAI, Inc.'s analysis of the LSR/pentane plus market supports the outlook that this outlet is likely to have declining value with gasoline demand peaking and the output of LSR/pentane-plus components are likely to increase with refineries running more light crude in the U.S. and more markets responding to ozone compliance requirements and decreasing the LSR/pentane plus used in gasoline, i.e. increasing LSR/pentane plus rejection out of finished gasoline and adding to the oversupply in the U.S. Gulf Coast. Another key observation with respect to capital costs is that two of the respondent refiners representing two significant refinery sources to the CFR market indicated they would not make 7.0 NWVR gasoline for the following two reasons:

1) Production is not viable with 10 % ethanol blending
2) The economics to produce and market this grade were less attractive than making 9.0 pound gasoline and shifting this grade to alternative markets with significantly higher transportation costs and lower netbacks than currently realized

Based on EAI, Inc.'s integrated supply-market analysis, it would be very difficult if not impossible for two significant refiner-suppliers in the DM/NFR NAA market to place on the order of 17 MBPD or 2720 MBBLS per year in other markets. It should also be noted that these two refiner-suppliers would also decrease their refinery output in addition to the gasoline grade and market shift.

Operating Cost and Lost Light End Value: It should be noted that operating costs, increasing opportunity costs, and higher costs for increasing gasoline blendstocks are not distinguished enough across the refinery surveys to accurately define and differentiate actual incremental refinery operating costs from these other incremental cost categories. The butane and LSR rejection costs, however are fairly representative of opportunity costs. Increasing rejection of these components is required with lower RVP requirements and specifying a no-1 psi blending waiver for ethanol. This represents a major increasing cost burden and risk for refiners with considerable uncertainty in the ability to place these streams in the market in the future and the value to be realized. The High Capital Intensity cases represent, to some extent, refiners reducing their LSR/pentane-plus market exposure as mentioned above. With increasing LSR marketing risk and lower value realization, refiners will likely be forced to invest in processes to convert the LSR/pentane plus materials to higher value products. As mentioned previously, this is part of what is being pursued with the Higher Capital Intensity refinery responses but with the burden of creating another risk in being able to push a significant amount of incremental 9.0 psi gasoline to other markets. Some of this incremental 9.0 psi gasoline, which is mainly concentrated in the Eastern Rockies could be directed to displace other sources of the same grade. This would have to be offset with increasing "imports" of compliant DM/NFR NAA gasoline from the other refiners that can access this market.

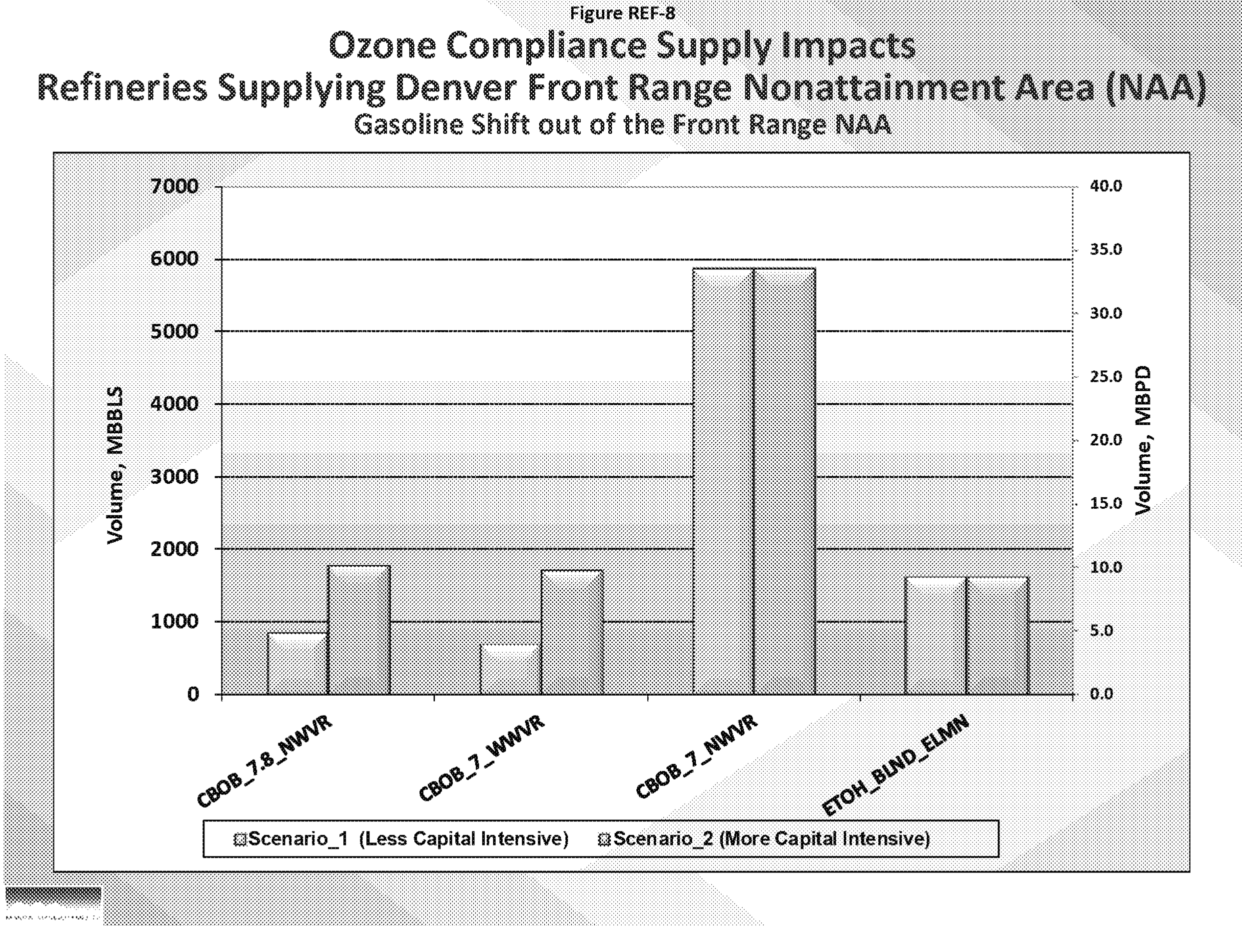
Impact on Supply Options: Some of the evaluated fuel options to achieve ozone compliance in the Colorado Front Range will most likely sever supply linkage with refiners north of Casper, i.e. Billings and refiners east and, south of El Dorado, Kansas. There is some open pipeline capacity to increase product movements into the Colorado Front Range / DM/NFR NAA but it is limited. The general availability of the gasoline grades being considered by the RAQC is limited in these alternative product sourcing areas and any upsets in the base supply for the DM/NFR NAA would be very difficult to replenish and would result in considerably higher end market costs than represented in the supply-cost analysis represented previously.

Potential Supply Loss: The Colorado Front Range is likely to experience a decline in available gasoline supply from current supply sources due to two major factors:

- Rejection of light ends (butanes & pentanes plus) to meet gasoline pool RVP limits. This volume is estimated to be in the range of 5 to 8 MBPD for the Low Capital Intensity scenarios and depending on the number of days assumed for the LRVP gasoline season. The Higher Capital Intensity scenario indicated less butane/LSR rejection with values more on the order of 2-4 MBPD. The "eliminate ethanol blending" case for both Capital Intensity Scenarios was the same at 6-8 MBPD during the low RVP season. A portion of this may be covered by increased ethanol blending either from ethanol blended into gasoline that is not blended now or via an increase in allowable ethanol blends, e.g. E15, increasing crude runs and/or producing other gasoline blendstocks such as isomerate and alkylate that would allow the use of greater quantities of lighter blendstocks.

- Some refiners have access to other markets and may shift gasoline to these markets to avoid the required capital investments in manufacturing some of the more stringent gasoline specs being considered for the Colorado Front Range market. The range of potential gasoline loss due to market shift is 4 to 11 MBPD across all the cases considered except the 7.0 NWVR case for which the potential lost supply to the DM/NFR NAA is on the order of 35-40 MBPD. These potential lost volumes are significant relative to open seasonal pipeline capacity servicing the CFR.

Figure REF-8



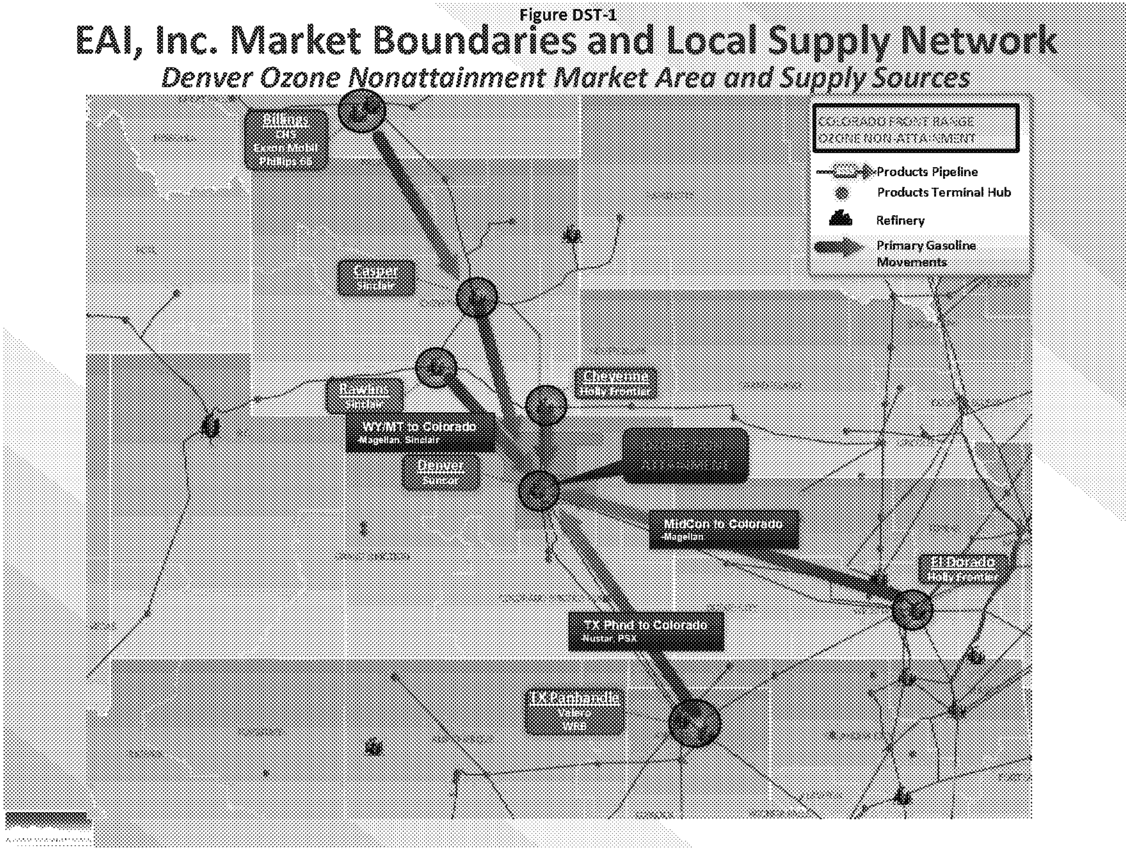
DST

DISTRIBUTION and MARKET IMPACTS

INTRODUCTION

In this section, potential impacts of changes to the summer gasoline grade specifications are discussed relative to potential changes to the supply of gasoline for the CFR market. The operation of the CFR Range supply network was detailed as to current operations and the linkage to primary supplying refineries was provided in the Overview section of this report. In review, there are six primary supply refineries to the Colorado market area. These six refineries, their locations and supply linkages are shown in **Figure DST-1** and described below:

Figure DST-1



- Suncor, Commerce City, CO – located directly in Denver/North Front Range market
- HollyFrontier, El Dorado, KS – supplies CFR via Magellan-Chase pipeline to Aurora, CO
- HollyFrontier, Cheyenne, WY - supplies CFR via Magellan pipeline to Denver (DuPont)
- Sinclair, Rawlins, WY – supplies CFR via Denver Products pipeline to Henderson, CO
- WRB, Borger, TX – supplies CFR via Phillips 66 pipeline to Denver
- Valero, McKee, TX – supplies CFR via NuStar and Phillips 66 pipelines to Colorado Springs and Denver

DISTRIBUTION IMPACTS

Refiners with significant alternative market options include WRB Borger, Valero McKee and HollyFrontier, El Dorado. These refineries have alternative markets of significant size and have product pipeline connections to these markets; however some are somewhat logistically limited and economically less attractive. Similarly, these same refineries in supplying significant volumes to alternative markets can choose to retract product from the alternative markets and send these volumes to Denver up to available pipeline capacity.

Refineries with limited alternative market options include Suncor Denver and HollyFrontier Cheyenne refineries. These refineries place a very large portion of their product in the CFR market area and if they did not invest to produce lower RVP gasoline (if mandated) then they would ultimately need to invest in new logistics to access alternative markets. The Suncor Denver refinery is a key supply source for the Denver/North Front Range. Loss of this volume via a decision to not make the more expensive, lower RVP gasoline product would be difficult to replace on a short term basis. In general, this replacement product would have to come from HollyFrontier El Dorado, WRB Borger and Valero McKee refineries with additional product being sourced in the Texas – Western Louisiana Gulf Coast area via Explorer and Magellan pipeline systems. In order for replacement supply to be accessible from the Gulf Coast, Magellan Midstream Partners would have to make investments in tankage for their pipeline system to accommodate lower RVP gasoline moving from the Gulf Coast through Tulsa and to Denver. In the case of HollyFrontier Cheyenne refinery, the potential volume loss of summer grade gasoline would necessitate significant volumes from outside sources (Magellan Chase, Valero McKee via NuStar, or WRB via Phillips 66 pipeline). Lastly, Sinclair Rawlins refinery places a significant amount of gasoline into the Denver/North Front Range, but could potentially shift that supply to alternative markets such as Salt Lake City and Las Vegas. In the case of both Sinclair and HollyFrontier Cheyenne, they could still provide 9 psi summer grade gasoline while other refiners outside Colorado could increase their volumes of nonattainment area gasoline. Large shifts of supply out of the CFR market would require alternative supply to replace it, but as mentioned previously in this report the capacity of pipelines supplying the market from areas that might have adequate supply availability (such as the Gulf Coast) are constraining and would need to be expanded.

Responses to the changes in gasoline grade specifications can take a number of forms including decisions to not supply the CFR market and reduction in the volume of specification grade gasoline and hence the volume supplied. Impacts of these decisions may be observed as retraction of attainment area gasoline from outlying markets, higher prices for gasoline product in the nonattainment area versus the attainment area, attainment area gasoline prices rising to levels similar to those in the nonattainment area and experiencing supply upsets due to a shrinkage in available fungible Denver/Front Range spec gasoline.

MARKET PRICE IMPACTS

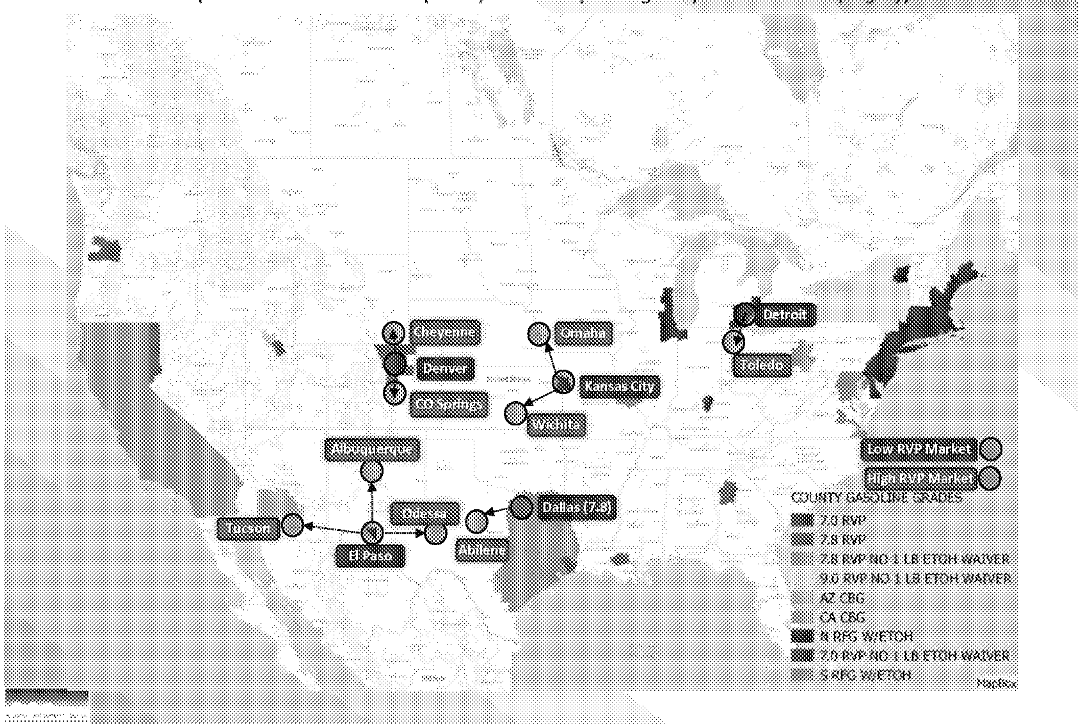
Figures DST-2 and DST-3 below show a comparison between regular gasoline prices (unbranded wholesale rack) for low RVP markets vs. higher RVP markets. This analysis assesses the potential price increase in lower RVP gasoline wholesale regular octane gasoline by comparing actual rack pricing in markets that require the use of lower RVP gasoline vs. rack pricing in markets where lower RVP gasoline is not required (9.0 psi RVP summer specification). For each low RVP market chosen, a market with higher RVP specification and similar logistics and supply sourcing was chosen for the basis of comparison.

The differentials, in cents per gallon, are calculated as the difference in average summer pricing (low RVP in effect, Jun. 1st – Sept. 15th) minus the difference in average winter pricing (Oct 1st – Apr. 30th) for the respective pairs of wholesale rack markets for the period of 2014 through 2018 YTD. The shoulder/transition months (May and Sept 16 – 30th) were omitted from the analysis. The results are summarized below:

Figure DST-2

Rack Wholesale Pricing Comparison: Low vs. High RVP

Map shows low RVP markets (in red) and corresponding comparison markets (in gray).



- **7.8 psi w/ ETOH waiver:** EAI, Inc. analyzed rack pricing in the Denver market, where 7.8 psi gasoline with the allowance of a 1 psi ETOH waiver is required and sold compared to the Cheyenne and Colorado Springs markets which have a maximum RVP specification of 9.0 psi in the summer months. On average, prices in Denver were 1.0 to 4.0 CPG greater than Cheyenne/Colorado Springs in the summer compared to winter when RVP specifications equilibrate. It should be noted that there is likely grade spillover of 7.8 psi gasoline into the 9.0 psi markets with more narrow cost differentials between the two grades relative to what is being considered for the fuel options addressed in this study. This would tend to narrow the gap between the two on pricing.

- **7.8 psi w/o ETOH waiver**: Similar to above, EAI, Inc. compared the prices of 7.8 psi RVP (no ETOH waiver) gasoline sold in the Dallas Metropolitan area vs. gasoline prices in the nearby Abilene market which has a higher maximum RVP specification of 9.0 psi. On average, prices in Dallas for 7.8 psi RVP gasoline with no ETOH waiver were 9.6 CPG greater than those in Abilene in the summer months compared to the winter months.

- **7.0 psi w/ ETOH waiver**: EAI, Inc. compared the prices of 7.0 psi RVP (with ETOH waiver) gasoline sold in the Detroit and Kansas City areas vs. gasoline prices in the nearby markets of Toledo and Wichita/Omaha, respectively, which have higher maximum RVP specifications of 9.0 psi. On average, prices in Detroit were 11.5 CPG higher than those in Toledo in the summer months compared to the winter months. Prices in Kansas City were 13.0 and 15.0 CPG higher than those in Wichita and Omaha, respectively, in the summer months compared to the winter months.

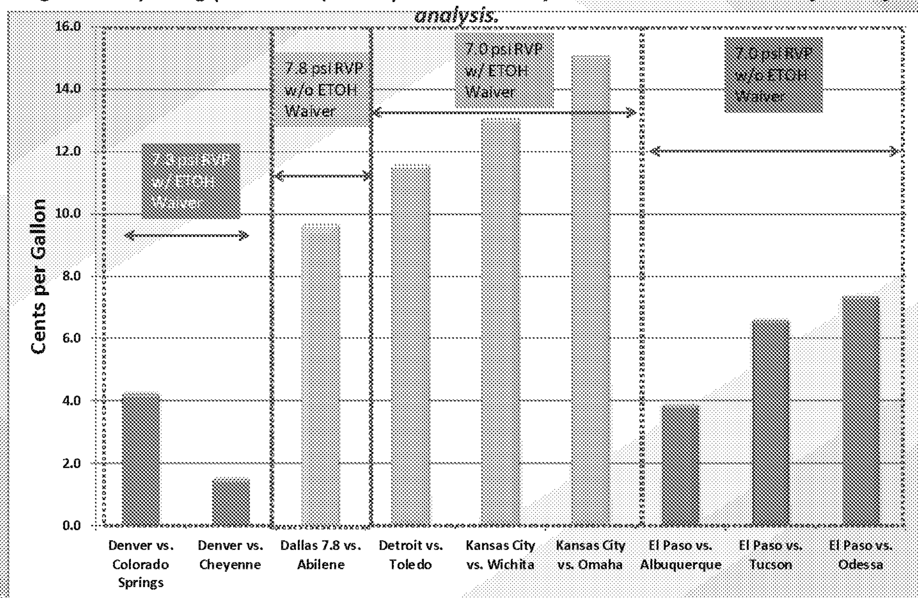
- **7.0 psi w/o ETOH waiver**: EAI, Inc. compared the prices of 7.0 psi RVP (no ETOH waiver) gasoline sold in the El Paso vs. gasoline prices in the nearby markets of Albuquerque, Odessa, and Tucson, which have higher maximum RVP specifications of 9.0 psi. On average, prices in El Paso were 3.8 to 7.3 CPG higher in the summer months compared to the winter months. This difference in price is significantly less than some of the less stringent gasoline types mentioned which is somewhat counterintuitive. Ultimately, a number of other variables could be driving the prices including low RVP gasoline supply availability (Gulf Coast produces a large quantity of Reformulated Gasoline which has similar RVP properties to 7.0 psi gasoline)

Figure DST-3

Low RVP Gasoline Price Comparison

Select Wholesale Racks: 2014 through 2018 YTD

Chart below shows a comparison between regular gasoline prices (unbranded wholesale rack) for low RVP markets vs. higher RVP markets. The differentials, in cents per gallon, are calculated as the difference in average summer pricing (low RVP in effect, Jun. 1st – Sept. 15th) minus the difference in average winter pricing (Oct 1st – Apr. 30th). The shoulder/transition months were left out of the analysis.



Source: EAI, Inc. analysis and interpretation of data from Opis

Implications and Caveats: The price comparison analysis is meant to give insight as to real world market prices for lower RVP gasoline vs. higher RVP gasoline. Higher prices for low RVP gasoline is influenced by increased refinery manufacturing cost and generally more restrictive supply availability. EAI, Inc.'s analysis indicates that there have often been 1.5 to 15.0 CPG market premiums paid for lower RVP fuels relative to 9.0 psi gasoline depending on the RVP specification. The CFR market already experiences short term, summer price increases (relative to Gulf Coast spot) and these would likely increase with a more stringent gasoline RVP specification. The CFR market tends to be more isolated than these other markets used in the comparison analysis and is likely to experience at least these levels of price increases related to the incremental cost of gasoline meeting the specifications of the evaluated strategies.

Generally the highest cost source of incremental volume required by the market sets the market clearing price. If there is considerably more supply than what the market can consume, prices will gravitate downward driven by surplus product spilling over into the attainment markets. The rack prices used in this analysis are subject to a number of other variables that affect price (gasoline RVP is not the only factor). As such, the differentials can be used as a general guide, but do not isolate the price as a function of RVP directly. EAI, Inc. chose a longer time frame (4+ years) as well as rack market pairs with similar supply-logistical structures (such as Detroit and Toledo) and players to limit the effect of other variables on price as much as possible.

BIO

BIOFUEL SUPPLY, DEMAND and IMPACTS

INTRODUCTION

Ethanol is a widely used motor gasoline blendstock in the United States and its use has been growing primarily as a result of the implementation of the Renewable Fuel Standard (RFS). Under the Federal Renewable Fuels Standard, EPA is charged with establishing the amount of renewable fuels that must be sold each year in the U.S. and basically this mandates increasing amounts of ethanol be blended into gasoline. Ethanol is also blended into gasoline because it is an effective fuel oxygenate, provides a significant boost in octane, and can provide an economic benefit to the blender as its overall cost is typically lower than the wholesale price of gasoline effectively providing a "blending margin".

A major consideration in the blending of ethanol into gasoline is the increased Reid Vapor Pressure (RVP) of the resulting blended product. In general, the cost of manufacturing gasoline for blending with ethanol increases as the mandated RVP of the final blended product is reduced. As a result, the increasing stringency of any given fuel strategy chosen will have increasing costs associated with it, depending on the ultimate gasoline specification product chosen. In addition, there are costs associated with not blending ethanol into gasoline resulting from increased RFS compliance costs, octane costs, and lost ethanol blending margin among others.

ETHANOL BLENDED GASOLINE

The most common gasoline-ethanol blends include ethanol blended up to 10 percent (E10), 15 percent (E15) and E85 (85 percent ethanol). Blending 10 percent ethanol into conventional gasoline increases the RVP of blended gasoline by about 1 psi. To account for this, the current Denver Metro/North Front Range specifications for summer time gasoline is for 7.8 psi RVP gasoline with a 1 psi RVP waiver for ethanol blended gasoline. This means that ethanol can be blended into regular specification grade gasoline and the resulting product is allowed a 1 psi RVP waiver on final blend RVP. The existence of a 1 psi waiver was established in the original EPA gasohol fuel waiver. Since any permissible increase in fuel volatility will result in increased evaporative hydrocarbon emissions (an ozone precursor), individual states have the right to disallow this waiver if required for air quality purposes. It is generally less costly to product gasoline with a 1 psi RVP ethanol waiver compared to producing gasoline with RVP specifications lacking the 1 psi RVP waiver. In states with no 1 psi waiver, a specially blended, low RVP gasoline product (CBOB) has to be blended with ethanol such that the final blend meets RVP limits. In general, CBOB manufacture requires removal of normal butanes or pentanes and greater amounts of alkylates to be added to gasoline in order to produce a specification grade gasoline product to be blended with ethanol that will be within the RVP standards.

The use of higher ethanol blends such as E15 and E85 can help to offset potential octane loss in producing lower RVP gasoline if an associated ethanol waiver is permitted. In October 2010, EPA approved E15 for use in model year 2007 and newer vehicles. In January 2011, EPA approved E15 for use in model years 2001 to 2006. The EPA is currently working to approve E15 summertime blending through the issuance of E15 blending RVP waivers. However, the transition to higher ethanol blends has been relatively slow in part due to inadequate infrastructure (retail stations with appropriate tankage and pumps) and fleet (vehicles permitted by the manufacturers to consume greater than 10 percent gasoline-ethanol blends). There are currently about 1400 sites offering E15, which is about 0.5% of the total fuel retail sites in the U.S. The pace of transition overall is likely to follow the pace of retail pump and fleet turnover to newer vehicles capable of handling higher blends.

BIOFUEL MANDATES

The Energy Policy Act (EPACT) of 2005 had provisions for mandated use of ethanol and other renewable fuels that increased over time. Following on this act, in December 2007, Congress passed the Energy Independence and Security Act (EISA 2007) that further increased the mandate for renewable fuels. EPA administers the RFS and each year determines the volume % of ethanol required in gasoline sold.

RFS Standards: Each year the EPA sets the renewable fuel percentage standards that must be met by obligated parties the following year. Obligated parties include refiners and importers of refined products. The finalized standards for total renewable fuel, advanced biofuel, biodiesel, and cellulosic biofuel for 2016, 2017, and 2018 are shown in **Table BIO-1** below.

Table BIO-1

EPA % STANDARDS, FINALIZED			
RENEWABLE FUEL	2016	2017	2018
CELLULOSIC BIOFUEL	**0.128%**	**0.173%**	**0.159%**
BIOMASS-BASED DIESEL	**1.59%**	**1.67%**	**1.74%**
ADVANCED BIOFUEL	**2.01%**	**2.38%**	**2.37%**
RENEWABLE FUEL	**10.10%**	**10.70%**	**10.67%**

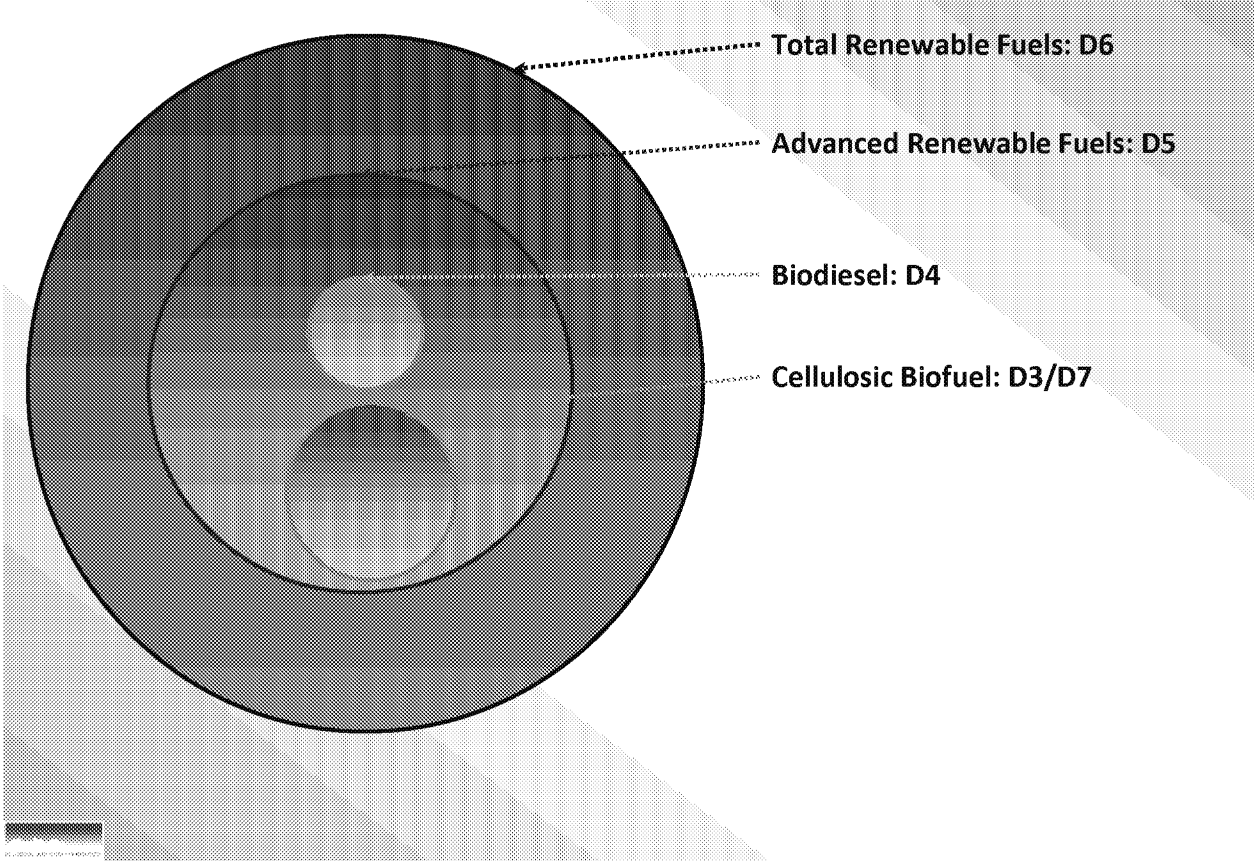
RFS Compliance: Refiners and importers must demonstrate compliance with RFS with submittal of RINs credits accumulated either through physical blending of renewable fuels into refined product (separated RINs), purchasing separated RINs credits from other parties, or carrying over separated RINs (limited to 20%) from the previous year. Obligated parties are also subjected to any carry-over RIN deficit from a previous year.

RVO (Renewable Volume Obligation) Calculation: The final EPA percentage standards are used to determine an individual party's RVO for a given year. The percentages, which are on an ethanol equivalent basis, are applied to a refiner or importer's total gasoline and diesel production for the year resulting in ethanol-equivalent renewable volume requirements. Because the resultant volume obligations are on an ethanol equivalent basis, one gallon of biodiesel physically blended usually is valued at 1.5 RINs credits towards meeting the standards.

Nested Nature of Fuel Standard and RINs Designation: The RFS requirements are built in a nested manner such that separated RINs credits generated for "higher level" biofuels can be used to meet requirements of biofuels at lower levels. This is illustrated in **Figure BIO-1** below For instance, although biodiesel has its own volume blend requirement, RINs (D4) generated from blending biodiesel into ultra-low sulfur diesel can be sold or used to meet blending requirements of the Advanced and Total Renewable Fuel standards. In fact, this has become fairly common as the ethanol 10% blend wall has largely prevented higher ethanol/gasoline blends (such as E85 or E15) from contributing significantly to the growing renewable fuels mandate. The difference between the Total Renewable Fuel standard and the Total Advanced Biofuel standard is typically met by blending corn-derived ethanol into gasoline and/or higher blends of biodiesel into ultra-low sulfur diesel.

Figure BIO-1

RFS Nested RINs Category Structure



RINs Pricing: The RINs market provides an early warning about changes in EPA policy. RINs credits pricing/value generally reflects the available supply of RINs which is dependent on available supply of biofuels and the ability to blend these biofuels into petroleum-based transportation fuels in order to generate separated RINs for complying with the RFS. RINs prices have been at historically high levels primarily as a result of the ethanol – gasoline 10%

blend wall combined with EPA's decision to increase RFS standards year over-year, although these have been typically revised downward annually from the original standards released in 2007. Infrastructure limitations as well as gasoline fleet composition has prevented large scale adoption of 15 and 85% ethanol blends in gasoline. As a result, increasing biodiesel blending percentages in ultra-low sulfur diesel has been the next most feasible/economic way to meet the more stringent RFS.

One of the options for gasoline emissions reduction is the banning of ethanol usage during the ozone season. Banning ethanol blending during the ozone season would conflict with the requirements of RFS as established under the Energy Policy Act of 2005 and later expanded under the Energy Independence and Security Act of 2007. Under the RFS, refiners in the United States are required to blend a certain amount renewable fuels into the transportation fuels that they produce during a given year. Accordingly, banning the use of E10 in the nonattainment area during the ozone season would prevent refiners serving the area from complying with their legal obligations under the federal RFS.

Recognizing that banning ethanol is not a legally viable option in light of the federal RFS mandate, a number of parties have suggested that Colorado could obtain a waiver from the federal RFS from EPA. While the Energy Independence and Security Act did provide EPA with waiver authority, the standards for granting such a waiver were set exceptionally high. Specifically, to grant a waiver, EPA must determine that one of two conditions has been met:

- There is inadequate domestic renewable fuel supply; or
- Implementation of the requirement would severely harm the economy or environment of a State, a region or the United States.

Because the basis for the waiver in the case for Colorado would be to allow the banning of ethanol during the summer months in order to achieve reduction of ozone precursor emissions, neither the domestic supply condition, nor the provision requiring severe economic harm would apply. An argument could be made that a waiver is justified in order to avoid harm to the environment. In considering a 2008 waiver request from the State of Texas, the EPA rejected an argument premised on the increase in ozone from using ethanol blending, concluding that the modest increases in ambient ozone levels that could result from the RFS mandate did not constitute severe harm as required under the statute. In light of this, the possibility of obtaining a waiver of the RFS would appear to be extremely remote.

In addition to being incompatible with federal RFS requirements, banning ethanol during the ozone season will not provide any appreciable ozone reduction benefit beyond the benefit achieved through elimination of the 1 pound ethanol waiver. In the context of ozone formation, ethanol blending in and of its self is not detrimental. Rather, what is harmful is ethanol blending in conjunction with the regulatory allowance of a 1 psi increase in RVP for E10 blended gasoline. If the waiver were eliminated, E10 gasoline would be no more volatile than conventional gasoline, and therefore the increase in ozone precursor emissions from the current use of E10 during the ozone season could be fully mitigated without resort to an ethanol ban.

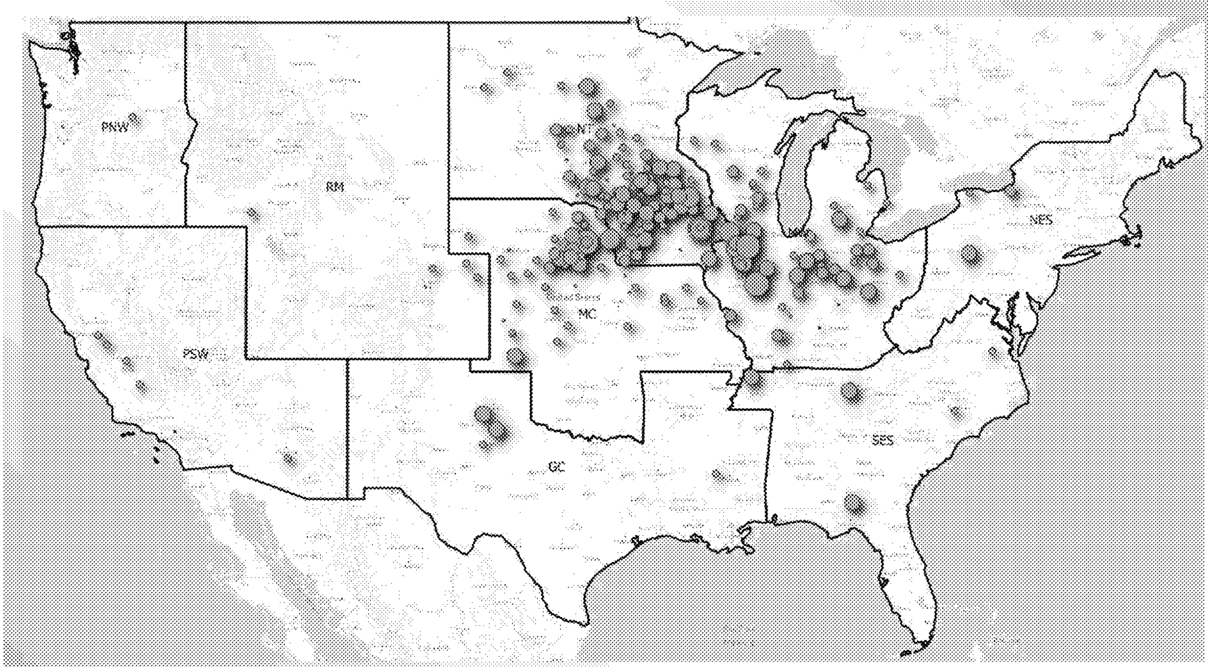
ETHANOL SUPPLY AND DEMAND

As stated previously, ethanol supply into the CFR market has grown in recent years as a result of increasing the increasing RFS as well as increasing gasoline consumption. The vast majority of U.S. ethanol supply is produced in the U.S. Central Corridor region (Northern Tier and Midwest sub-regions – see **Figure BIO-2**). Total ethanol production through May 2018 averaged 15817 MMGal/Year, > 90% of which was produced in the U.S. Central Corridor. Substantially all of the U.S. ethanol production utilized corn starch as a feedstock. U.S. exports of ethanol have averaged about 700 MMGal/Year in 2018.

Figure BIO-2

U.S. Ethanol Plants

Current capacity of operating ethanol plants (green circles) is 16.3 BGY.



Plants represented by circles sized according to production capacity

Ethanol is primarily transported via rail and truck as it generally cannot be transported via pipeline. Most of the production in the U.S. Central Corridor is moved to other parts of the U.S. via rail. **Figure BIO-3** illustrates this and shows regional flows and balances for ethanol.

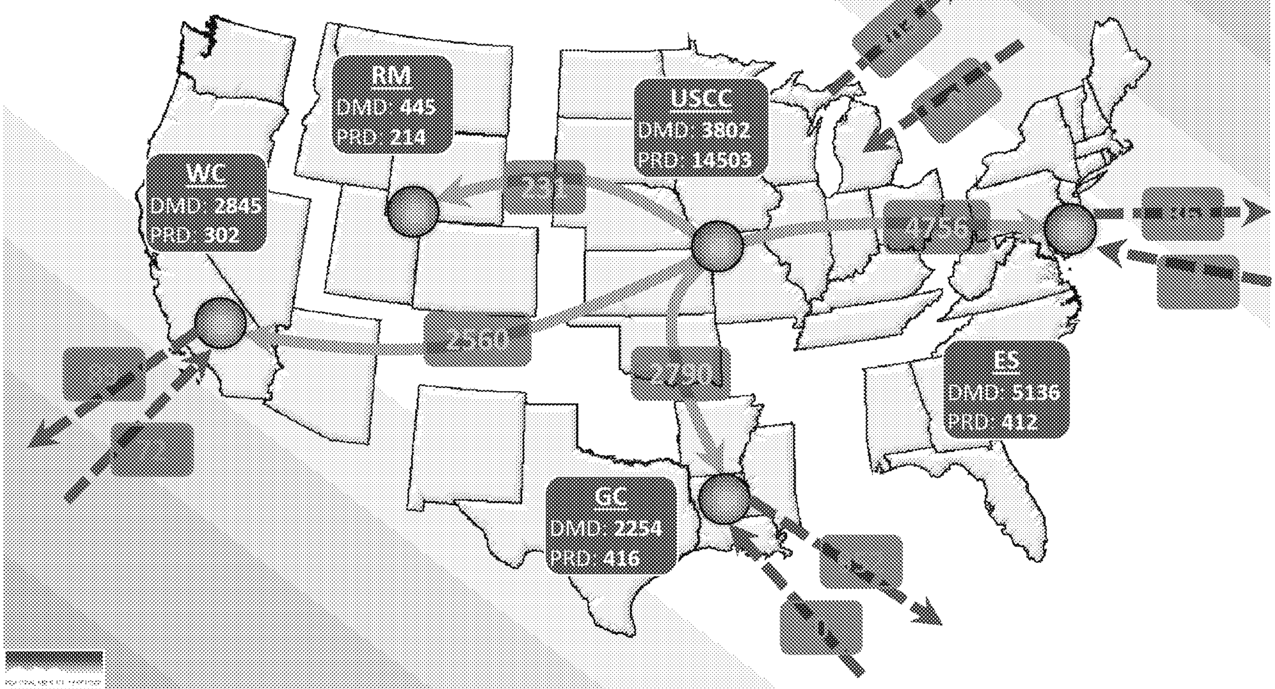
The U.S. % of ethanol in gasoline consumed likely hit the 10% blend wall in late 2012, early 2013, and has largely remained there ever since. Infrastructure and market interest to support blends above 10% does not currently exist at a large scale in most U.S. markets. Consequently, increasing volumes of biodiesel have been blended into finished diesel to generate additional RINs credits towards RFS.

Suppliers to the CFR market source ethanol from plants located in CO (151 MMgal/Year) and from plants located outside of the state. There is enough capacity at the CO plants to supply all of the CFR market; however some of the production likely is exported outside of the state. Ethanol supply to the CFR market has grown from 8 to 15 MBPD between 2011 and 2017. In addition, biodiesel supply has grown and now accounts for approximately 4% of the diesel pool.

Figure BIO-3

EAI, Inc. U.S. Ethanol Balances
2017, MMGal/Yr

The majority of U.S. ethanol is produced in the U.S. Central Corridor and moves to outlying markets mostly via rail. Some ethanol moves by barge on the Mississippi and Ohio rivers. Only one product pipeline moves ethanol and this is CFPL from Tampa to Orlando. Brazilian ethanol imports have declined necessitating more biodiesel usage in order to meet the Advanced Biofuel RFS. Most Brazilian ethanol imports are imported on the West Coast to meet CA and OR LCFS requirements.



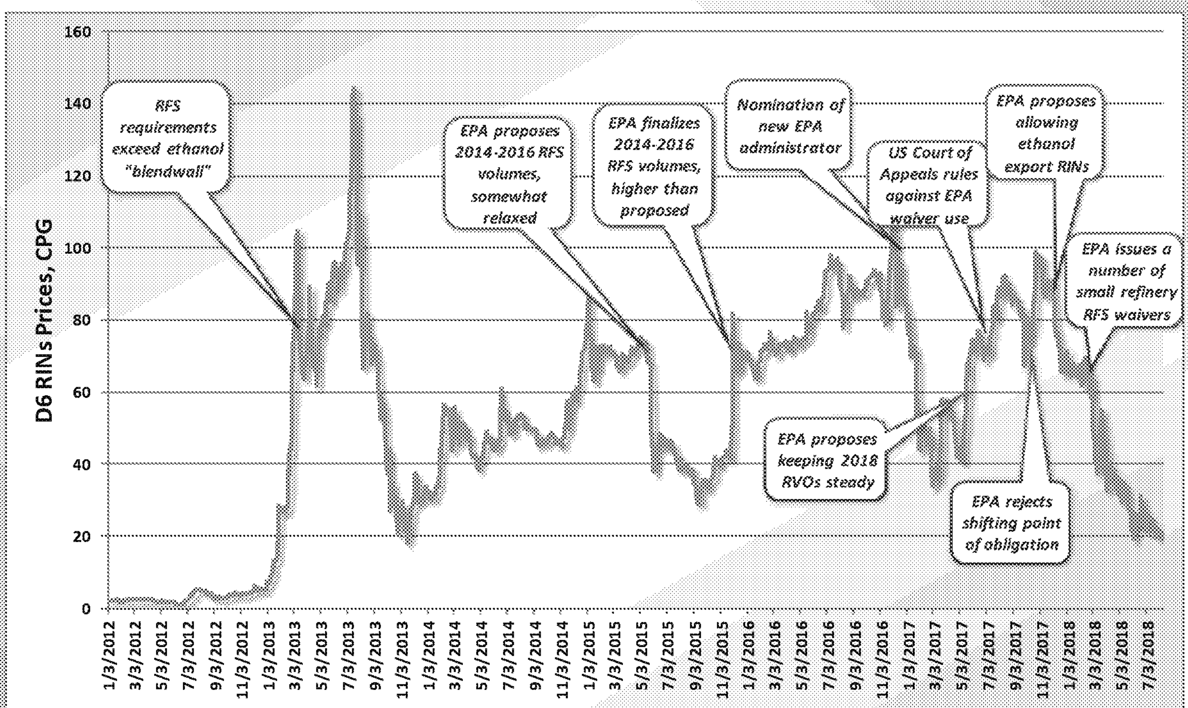
Biofuel usage as a percentage of finished fuel product in the Rocky Mountain as a whole generally lagged that of the U.S. due to small refiners (<= 75 MBPD atmospheric crude tower capacity) having been exempt from RFS until 2011. However, after 2011 small refiners had to demonstrate disproportionate economic hardship through waiver applications in order to qualify for RFS exemptions. The EPA subsequently turned down most exemption applications as many of the refineries did not meet EPA's criteria at that time. Between 2012 and 2016, most of the Rocky Mountain refineries were held to the same RFS standards which contributed to the growth of biofuel supply as did overall growth in fuel consumption. EPA's denial of Sinclair's RFS small refiner exemption application was ordered to be reversed by the federal courts in the summer of 2017. The court stated that EPA wrongly defined an economic hardship as the threat of going out of business. The EPA will now have to look at economic hardships in relative terms. This sets new precedence on EPA review of future small refinery economic hardship cases which has led to the EPA exempting 33 refineries (as of June 2018) from the 2017 RFS including a number of refineries in the Rocky Mountains. The exemptions were granted after the 2017 RFS blend levels had already been set leading to increased available RINs supply and a subsequent RINs price drop. Going forward, the EPA will likely factor in exemptions into future RFS blend levels in the face of increasing scrutiny from biofuels and agricultural groups. The result could be the biofuel blending onus shifting more to large refiners (>75 MBPD atmospheric crude tower capacity).

Renewable Identification Number (RINs) credit prices have increased significantly as a result of the 10% blend wall being reached over the 2012-2013 period. One of the primary mechanisms for the increased RINs prices was biodiesel becoming the incremental biofuel blendstock as ethanol became more limited by the blend wall. **Figure BIO-4** below shows the dramatic increase in RINs prices and some of the factors that have caused volatility.

Figure BIO-4

RINs Cost per Gallon

D6 (Corn Produced) RINs prices escalated in late 2012/early 2013 as banked RINs started drawing down due to less than expected gasoline demand and the resultant approach to the 10% ethanol blend wall. Since then, they have been very volatile as a result of uncertainty regarding the EPA/government's stance on RFS and in future renewable volume obligations. Recent small refinery RFS waivers have brought down RINs pricing to their lowest levels in 5 years.



Source: EAI, Inc. and Argus

ETHANOL BLENDING ELIMINATION IMPACTS

Ethanol has evolved into a very important blending component for refiners even when excluding the RFS incentive to blend. Typically, refiners supply regular "subgrade" gasoline to the CFR market which typically has a posted octane number (PON - average of the research and motor octane numbers) of 81 to 82, whereas regular gasoline at the pump typically has a PON of at least 85. Blending 10% ethanol gives refiners a 3 to 4 octane point boost on average. This is typically a more economical way to produce octane than refinery-centric methods such as the operation of reformer units at higher severity. In addition, ethanol as a blending component is typically less expensive than the going market rate for gasoline, meaning refiners/suppliers can realize a "blending margin" by blending ethanol.

Eliminating the blending of ethanol in the CFR nonattainment area would increase costs to the refiner/supplier, which would ultimately be passed through to consumers and, and eliminate a large market for the local Colorado ethanol producers as well as some out-of-state ethanol producers. These impacts are summarized below:

1. **RINs credit purchase requirement:** Both the obligated and non-obligated parties selling gasoline in the nonattainment area would lose RINs credits associated with ethanol blending in gasoline (one RIN-gallon detached for every one ethanol gallon blended) Blending ethanol into gasoline is the primary method refiners (obligated parties) use to comply with the RFS through retiring separated or detached RINs credits. Non-obligated parties such as marketers and wholesalers which blend ethanol can sell detached RINs credits to obligated parties at market-based RINs prices.

2. **Lost ethanol blending margin:** As mentioned previously, there is typically margin associated with ethanol blending as the ethanol is typically less costly than the gasoline market/wholesale prices.

3. **RINs credit indirect purchase requirement:** With the retraction of ethanol supply to the CFR nonattainment area, there would need to be increased gasoline supply to replace it to meet demand. Refiners and suppliers would ultimately be shifting gasoline supply from external markets to the CFR market and forgoing ethanol blending and thus RINs value capture in those external markets. In addition, the octane loss resulting from eliminating ethanol from gasoline mentioned below could increase the need for increased gasoline supplies as refiners back out various low octane components such as LSR (light straight run naphtha).

4. **Associated octane loss:** As mentioned previously, ethanol provides a valuable octane lift to gasoline. Eliminating ethanol from gasoline would require refiners to boost octane of the gasoline blendstock at the refinery. Excluding capital investments, this could involve more costly processes such as backing out LSR (light straight run naphtha) blendstocks, running the reformers at higher severity, and blending other octane boosting components such as iso-octane. Given the potential for octane demand increasing in the CFR market, this could become increasingly costly for refiners.

5. **Loss of significant ethanol market for ethanol producers:** Colorado's four local ethanol producers (Front Range Energy, Merrick/Coors, Sterling Ethanol, and Yuma Ethanol) have a total production capacity of 151 MMGal/yr and are the largest suppliers of ethanol to the CFR market. The elimination of ethanol blending in the Colorado NAA would result in the loss or displacement of approximately 55 MMGal/yr of ethanol

consumption associated with summertime blending. As a result, the local producers that are most economically advantaged to supply the CFR may become economically disadvantaged in having to place additional product in more distant markets. Because the refiners supplying the NAA would still be obligated to demonstrate RFS compliance in the absence of a federal issued waiver (through increased RINs purchases and/or greater biofuel blending in other markets), additional ethanol or other renewable fuels would have to be blended elsewhere to make up the RINs shortfall.

6. **Replacement supply logistics constraints:** Eliminating ethanol from the gasoline blend pool would effectively require that more base gasoline blendstock be consumed in its place. As a result, the existing pipeline and terminal infrastructure would ultimately see greater loading (on the order of 10 MBPD during the low RVP season) and would potentially exacerbate the existing constraints.

7. **Terminal tank storage limitations:** By eliminating ethanol from gasoline blending during the summertime, a need is created for an additional gasoline blendstock (regular octane, finished gasoline for summertime sales) and associated storage as well as the initial storage in place for sub-octane and ethanol blendstocks (non-NAA and wintertime gasoline sales). Additional capital investments would have to be made in many of the Denver area supply terminals to accommodate this additional gasoline blendstock.

EAI, Inc. quantified factors 1 through 3 for the CFR nonattainment market as a whole taking into account both regular and premium gasoline consumption in the market. The estimated minimum cost of ethanol blending elimination as shown below in **Figure BIO-5** would be 9.4 CPG (cents per gallon). This cost was calculated using 2017 average annual unbranded wholesale rack pricing for Denver (from OPIS), D6 RINs pricing (from Argus), NE spot ethanol pricing (from Argus), and EAI, Inc.'s estimate for ethanol rail transportation from Omaha, NE (where Argus spot pricing is based).

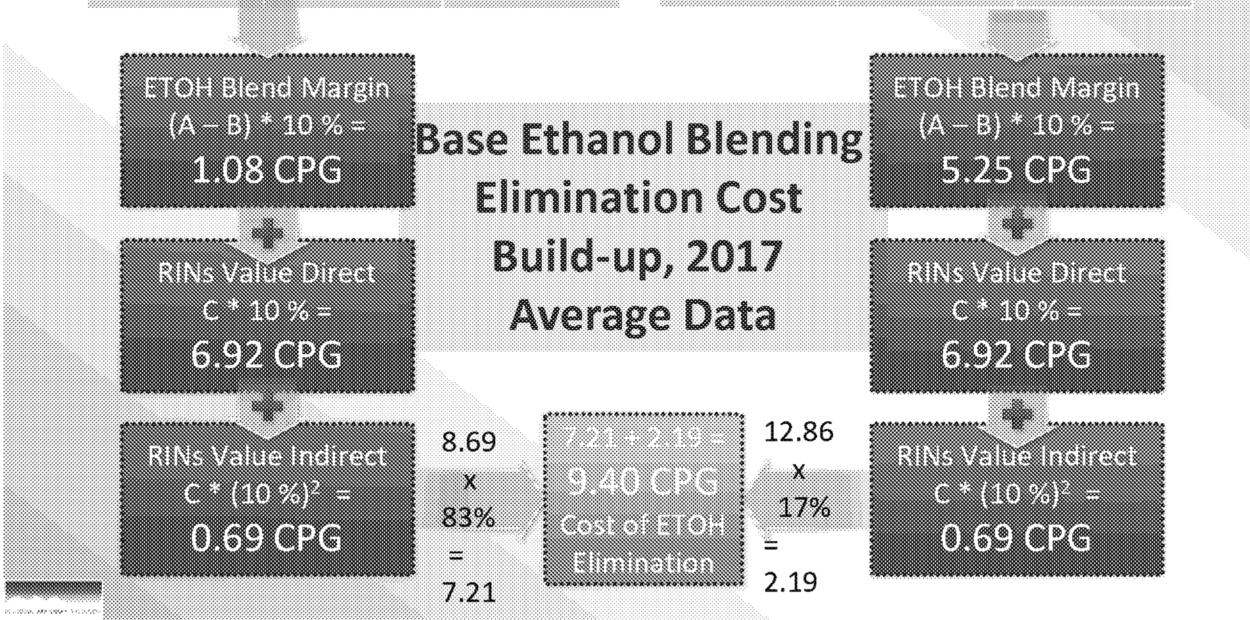
This does not factor in the possibility that market RINs prices could increase as a result of greater demand resulting from the CFR nonattainment loss of ethanol blending. It also does not factor in the added costs from actor number four from above was somewhat captured in the refinery survey as explained further in this report.

The Rocky Mountain region is home to a number of small refineries (<= 75 MBPD crude tower capacity) which are eligible for RFS small refinery economic hardship waivers. A number of these refineries were able to obtain RFS waivers from the EPA for the compliance year 2017; however they would still ultimately lose the RIN value by forgoing ethanol blending.

Figure BIO-5

Regular Gasoline: 83% of NAA Consumption		
A	Denver Reg. Rack Price, CPG	171.72
B	ETOH Laid-in Cost, CPG	160.93
C	D6 RIN Value, CPG	69.23

Premium Gasoline: 17% of NAA Consumption		
A	Denver Prem. Rack Price, CPG	213.47
B	ETOH Laid-in Cost, CPG	160.93
C	D6 RIN Value, CPG	69.23



REG

PRODUCT REGULATIONS

INTRODUCTION

Fuel products in Colorado are regulated to ensure product consistency, attainment of performance standards, insurance that public safety considerations are met, as well as to minimize environmental impacts resulting from the production and transportation of and the use of motor vehicle fuels. In the United States, it is the U.S. EPA that in many cases determines fuel properties that are necessary to meet national priorities concerning the environment. On a more local level, it is the lead planning agencies such as the Regional Air Quality Council (RAQC) and the Colorado Department of Public Health and Environment (CDPHE) that propose fuels strategies and programs considered and adopted by the Colorado Air Quality Commission.

In this section, product regulations that impact gasoline specifications are reviewed with emphasis on those facets that may impact Colorado's decision process in selecting a gasoline formation for its SIP program for reducing ozone pollution. Topics included in this review are; background on ozone pollution, gasoline specification grades instituted to reduce ozone pollution, and other major past and future gasoline regulations which impact gasoline production, production costs, and supply distribution patterns.

OZONE POLLUTION

Gasoline in the Denver area nonattainment area (NAA) is regulated to reduce summertime fuel volatility as a result of this area's violation of the federal National Ambient Air Quality Standards for ozone. As a result of this noncompliance, the U.S. EPA requires that summertime gasoline distributed and used in the Denver North Front Range's eight-hour ozone nonattainment area be limited to a maximum volatility of 7.8 pounds psi, as measured by the Reid Vapor Pressure (RVP) test.

Reduction in summertime fuel volatility results in a reduction of hydrocarbon evaporative emissions which is one of the principle precursors in the formation of tropospheric ozone. Ground-level ozone pollution (sometimes called "smog") is formed by the reaction of volatile organic compounds (VOC) and nitrogen oxides (NOX) in the atmosphere in the presence of sunlight. These two pollutants, often referred to as ozone precursors, are emitted by many types of pollution sources, including on-road and off-road motor vehicles and engines, power plants and industrial facilities.

In 1979, EPA promulgated the 120 ppb, 1-hour ozone standard, as part of attainment of National Ambient Air Quality Standards (NAAQS) under the Clean Air Act (CAA). Colorado violated this standard throughout most of the 1980s, with the Denver metro area being designated a 7.8 lb. RVP (with 1 psi waiver for ethanol blending) gasoline area as a result. However, due to the demonstrations via review of air monitoring data, the area was granted a series of waivers from this requirement.

On July 18, 1997, EPA promulgated a revised standard of 80 ppb, measured over a longer 8-hour period (i.e., the 8-hour standard) to meet requirements of 1990 amendments to CAA. The longer period was thought to represent a more realistic exposure environment, though with a reduced average concentration limit. In general, the 8-hour standard was more protective of public health and more stringent than the 1-hour standard. Nationally there were many more areas that did not meet the 8-hour standard than there were areas that did not meet the shorter peak 1-hour standard. This included the Denver North Front Range areas. As a result of Colorado's adoption of its eight-hour ozone attainment State Implementation Plan (SIP), the 7.8 lb. low RVP summertime gasoline standard was re-imposed on the Denver area and the overall area was expanded into the more northerly counties of Larimer and Weld.

On March 12, 2008, EPA significantly strengthened its national ambient air quality standards (NAAQS) for ground-level ozone by revising the 8-hour "primary" ozone standard, to a level of 75 ppm. EPA also strengthened the secondary 8-hour ozone standard to the level of 0.075 ppm making it identical to the revised primary standard. Colorado has frequently been in violation of this standard.

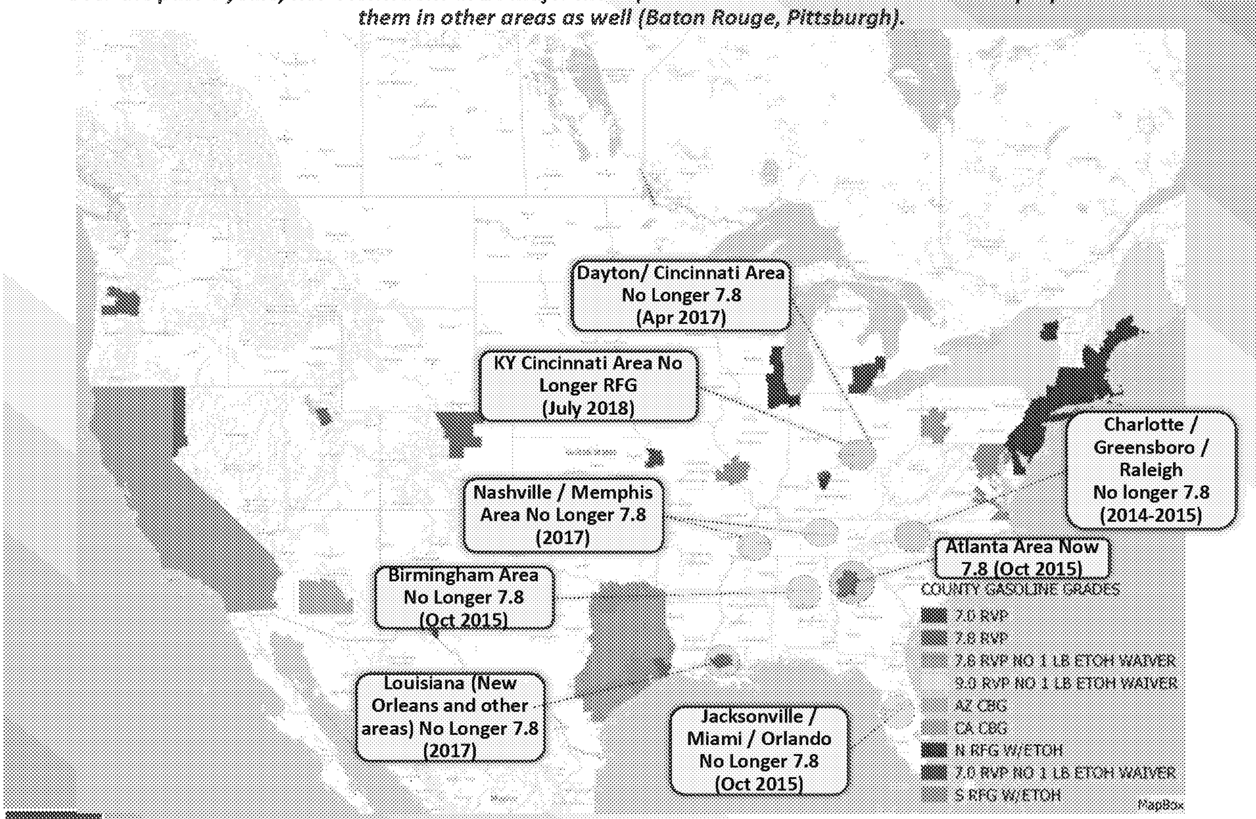
The EPA finalized revisions to the NAAQS for ground-level ozone concentrations and strengthened the standard from 75 ppb to 70 ppb on October 1, 2015. When the 75 ppb level was set in March 2008, 168 counties in 17 states were classified as nonattainment areas. With the new 70 ppb concentration level, 200 counties in 22 states would be classified as nonattainment according to 2014-2016 monitoring data.

A number of metropolitan areas across the U.S. have summer gasoline RVP restrictions, some of which match the proposed Colorado NAA specifications. **Figure REG-1** below highlights the gasoline grade requirements across the U.S. Over the past 4 years, RVP restrictions in 14 major metropolitan areas have been relaxed and there are proposals to relax them in other areas as well (see **Figure REG-1** below) as a result of these areas coming into ozone attainment. As a result, there will likely be less production of these lower RVP fuels and generally less supply availability. There may also be less incentive for refiners to produce these fuels as the number of market outlets and subsequent consumption declines. However, the lower limit of 70 ppb could push more metropolitan areas into nonattainment and may further require more stringent gasoline RVP specifications as part of the mitigation strategies.

Figure REG-1

U.S. Summer Gasoline Restrictions (RVP)

Over the past 4 years, RVP restrictions in 14 major metropolitan areas have been relaxed with proposals to relax them in other areas as well (Baton Rouge, Pittsburgh).



Source: EAI, Inc. and EPA

THE SIP PROCESS

States use the SIP process to identify the emissions sources that contribute to the nonattainment problem in a particular area, and to select the emissions reductions measures most appropriate for that area, considering costs and a variety of local factors. Under the Clean Air Act, SIPs must ensure that areas reach attainment as expeditiously as practicable. However, other programs, such as Federal controls, also provide reductions and States may rely on those reductions when developing their attainment plans.

GASOLINE REGULATIONS: MOBILE SOURCES AIR TOXICS

With the Mobile Source Air Toxics (MSAT2) final rule, beginning in January 1, 2011, importers and most refineries were required to import or produce gasoline containing no more than 0.62 vol% benzene on an annual average basis. This average 0.62 vol% benzene standard could be met by using credits. Beginning in July 1, 2012, importers and most refineries were required to import or produce gasoline with a cap or maximum annual average gasoline benzene content of no more than 1.3 vol%. Credits could not be used to meet the 1.3 vol% standard. Small refiners (<= 155 MBPD atmospheric crude tower capacity, <=1500 company-wide employment) were allowed an additional four years to comply with each benzene standard. They were required to start complying with the 0.62 vol% standard no later than January 1, 2015, and begin complying with the 1.3 vol% standard no later than July 1, 2016. Some of the more common refinery implementations to reduce benzene content of gasoline include naphtha splitters, more selective isomerization, benzene saturation units, and benzene extraction units. These implementations generally made it more difficult to meet minimum octane specification in gasoline as the benzene and other aromatic compounds being taken out of the gasoline or saturated with hydrogen are typically higher octane components with relatively low RVP.

GASOLINE REGULATIONS: TIER 3 GASOLINE SULFUR CONTENT

With EPA's Tier 3 gasoline sulfur regulations, the refiner and importer gasoline maximum sulfur concentration on an annual average basis was set at 10 ppm beginning in January 1, 2017 and on a per gallon basis the maximum sulfur concentration was set at 80 ppm. Small refiners (classified as either <=155 MBPD capacity and <=1500 employees company-wide, or <= 75 MBPD capacity) have delayed compliance until January 1, 2020. Reducing the sulfur in gasoline generally involves more severe hydrotreating (and associated sulfur recovery processes) of either the gasoline blending components themselves, or the feedstocks involved in producing gasoline such as naphtha and gas oils.

GASOLINE REGULATIONS: PROPOSED MINIMUM OCTANE GASOLINE AND RFS RESET

There has been discussion in congress initiated with the 21st Century Transportation Fuels Act draft bill which is composed of two primary initiatives:

1) Phasing out the current RFS in 2023 and implementing a new program which would set renewable fuel requirements for advanced biofuel, cellulosic biofuel, and biodiesel at levels equal to the production of those fuels during the past calendar year. This ultimately leaves out traditional ethanol sources such as corn-derived and focuses entirely on advanced biofuels. Current production levels of cellulosic ethanol and other advanced biofuels have lagged the annual blend targets laid out initially by the RFS and as a result have been continually revised by the EPA.
2) Requiring automobile manufacturers to produce vehicles which operate on gasoline that has a minimum research octane number of 95 and warranty these vehicles to operate on gasoline-ethanol blends of up to 20% ethanol by volume.

This bill looks to incentivize ethanol blending through increased octane and fuel performance requirements rather than increased blending requirements as ethanol one of the lowest cost octane enhancers available. This would tend to make it more economically attractive to blend ethanol into gasoline and thus more costly to forgo ethanol blending as a way of lowering gasoline RVP. However, it is not certain that various constraints such as retail site ethanol infrastructure would be in place in time and as such many refiners would have to make capital investments to product higher octane gasoline. This would tend to be exacerbated when overlapping lower RVP requirements due to the high octane butane rejection.

APX

GLOSSARY OF TERMS

TERMS AND DEFINITIONS

ALKYLATION	Refinery process for combining light hydrocarbon olefins to produce alkylate, a high octane gasoline blendstock
BARREL	42 U.S. Gallons
BART	Best Available Retrofit Technology
BLENDING	Refinery process where petroleum blend stocks of differing octane levels and vapor pressures are combined in order to produce finished product gasoline
BPD	Barrels per day, volumetric rate
C5	Pentanes, see below
CAA	Clean Air Act
CB6	Carbon Bond 6
CBG	Arizona Cleaner Burning Gasoline
CBI	Caribbean Basin Initiative countries - Certain Caribbean nations that have been authorized to distill wet ethanol feedstocks and produce dry fuel ethanol for import into the U.S. without duty
CBOB	Conventional gasoline blendstock for blending with ethanol
CDOT	Colorado Department of Transportation
CFR	Colorado Front Range: Area East of the continental divide; contains the most population, & refined product demand. Major metropolitan areas: Denver, Boulder, Colorado Springs, Castle Rock, Fort Collins, Greeley
CO	Carbon Monoxide
COGCC	Colorado Oil and Gas Conservation Commission
COKING	Refinery process to thermally crack large molecule petroleum vacuum resid into smaller molecule, lighter petroleum liquids
CPG	Cents per gallon
DENVER NFR/DNFR	Colorado ozone non-attainment area includes Adams, Arapahoe, Boulder, Broomfield, Denver, Douglas, Jefferson, Larimer and Weld counties
DE-PENTANIZER	Refinery processing unit designed to remove pentane from naphtha streams
DM/NFR	Denver Metro/North Front Range
EG	Emission Guidelines
FHWA	Federal Highway Administration
LIGHT ENDS	Low temperature boiling fractions of petroleum hydrocarbons. Generally refers to low density (light) hydrocarbons butanes and pentanes which have high volatility, i.e. high vapor pressure.
LRVP	Low RVP, gasoline with lower RVP than standard conventional gasoline for a given season and locale
MBPD	1000s of barrels per day, volumetric rate
MC_GC	Includes the Midcontinent and Gulf Coast regions
NAA	Ozone nonattainment Area
NFR	North Front Range
NWVR	No ethanol waiver
OCTANE	Standard measure of gasoline ability to burn in a standard spark ignition engine without producing engine "knocking" or harmful vibration. Iso-octane molecule rated as 100 octane. Standard automobile engines require gasoline of a minimum octane rating to perform without knocking.

OLEFINS	Generally small hydrocarbon molecules with at least one double bond between adjacent carbon atoms. In refinery processing, most olefins are produced in cracking processes (fluid catalytic cracking and coking). Light olefins are more unstable and generally will polymerize or react with other molecules producing off-specification products over time. Minimum specifications are set for olefins in gasoline.
PENTANES	Five carbon straight chain hydrocarbons found in crude oil, natural liquid condensate and produced by refinery operations. A high RVP liquid hydrocarbon.
POLYMERIZATION	Refinery process for combining light hydrocarbon olefins to produce higher octane naphtha blendstock for gasoline blending – gives lower yields than alkylation
PPB	Parts per Billion
PPM	Parts per Million
PSI	Pounds per square inch, measurement of pressure, especially gaseous pressure. Standard unit of measure of Reid Vapor Pressure (RVP).
RBOB	Reformulated Gasoline blendstock for blending with ethanol
REFORMING	Refinery process for increasing petroleum naphtha octane levels by catalytically reforming straight chain molecules into branched chain and ring compounds
RESID	Generally, the highest boiling portion of crude oil (boiling above 1000 degrees Fahrenheit) – used either for asphalt cement, road oils, residual fuel oils or coker feedstocks. Referred to as bottom of the barrel or bottoms.
RFG	Reformulated Gasoline
RFS	Renewable Fuels Standard, generally a percentage of the motor fuels marketed by a company that must be a set amount of renewable fuel. Set annually by the EPA as directed by EISA, or previously EPACT.
RIN's	Renewable Identification Numbers – Assigned to batches of renewable fuel blendstocks at the time of transfer from producers or importers to other participants in the fuel supply business.
RVP	Reid Vapor Pressure, standard measure of the vapor pressure of gasoline, important property in gasoline volatility. Maximum volatility of gasoline is seasonally regulated to reduce engine operation problems and reduce emissions.
TX_PHNDL	Region including the Texas Panhandle where the WRB and Valero refineries are located
VMT	Vehicle Miles Traveled
WESTERN SLOPE COLORADO	Generally the area west of the continental divide. Major metropolitan area – Grand Junction
WY_MT	Region including the states of Wyoming and Montana

APX-B

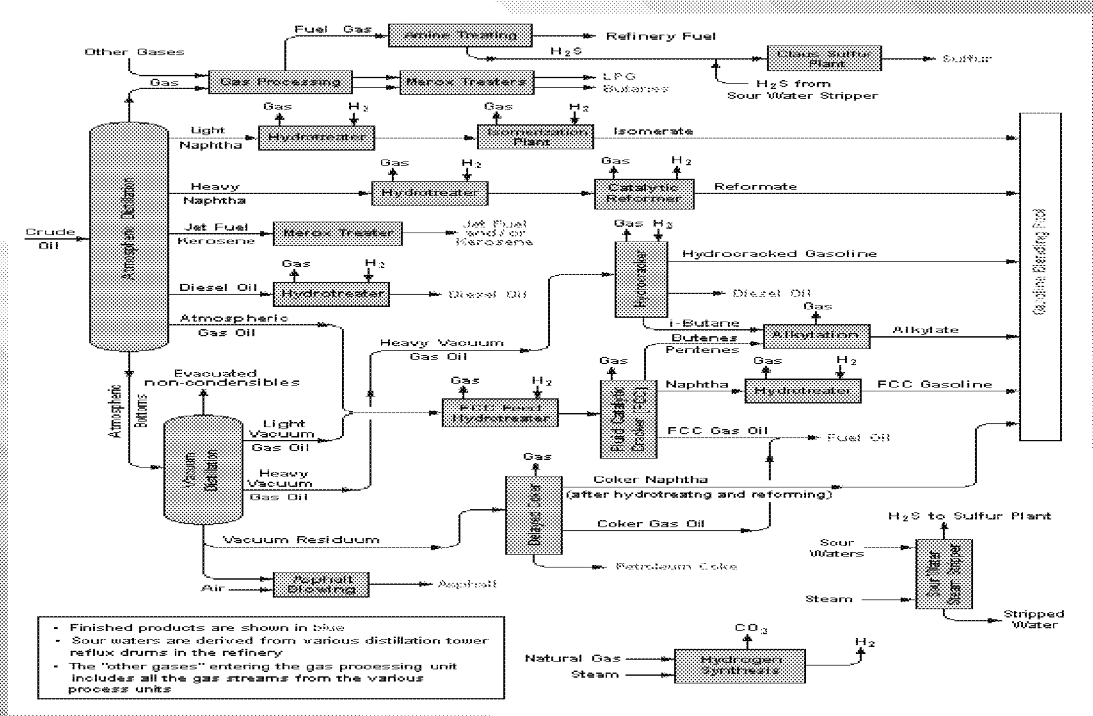
REFINERY PROCESSES OVERVIEW

REFINERY PROCESSES OVERVIEW

Refineries utilize a variety of operations that are used to produce finished gasoline and other products from crude oil and other feeds and blendstocks. Depending on specifications of the finished product, the physical setup of the refinery, and the type and quality of the crude oil used, different interconnected operations and refinery units are emphasized. In these processes, crude oil is separated into various cuts (boiling point ranges) that then are further refined and separated into various refinery streams. In the case of gasoline, the finished refined components are then blended together to produce specification grade gasoline. A generalized process flow diagram of petroleum refining operations can be used to illustrate this process, as is shown in **Figure APX-B-1**. For clarity, each of the six refineries evaluated in this study is different and none of the refineries has all of the units described in the general listing. As noted above, each of the refineries has a different array of processing units and has different processing capabilities.

Figure APX-B-1

Generalized Refinery Process Schematic



Atmospheric crude distillation tower: This unit is the primary refinery processing unit. In this unit, crude oil is distilled and separated into various fractions by boiling range (relative volatility). These fractions, in order of increasing density, include light petroleum gases, light naphtha, heavy naphtha, jet fuel and kerosene, distillate fuels, gas oils, and atmospheric tower bottoms. In general, refineries are classified according to the capacity of their atmospheric crude distillation unit(s) in barrels per day of crude input.

Vacuum distillation tower: This unit further distills atmospheric tower bottoms into vacuum gas oil and vacuum tower bottoms using lower temperatures afforded by reduced operating pressure. Vacuum gas oil is processed further in a Fluid Catalytic Cracking unit (FCC) described below. The vacuum tower bottoms are either processed in a coking unit, asphalt unit or blended into various residual fuel oil products.

Fluid catalytic cracking: The FCC unit cracks large molecule gas oils via catalytic cracking over fluidized zeolite catalyst into light petroleum fractions, naphtha and distillates. The FCC naphtha, also known as cat gasoline, is sent to gasoline blending and the distillate is sent to distillate treating for blending into diesel and fuel oil products. In many cases, the gas oil feed for the FCC unit is upgraded by catalytic hydrotreating or hydrocracking in order to remove sulfur and impurities and improve light product yields. Some of the major products of FCC processing are light olefins which are light unsaturated hydrocarbons, these are processed further in either an alkylation or a polymerization unit described below to produce high octane alkylate or cat poly gasoline.

Hydrocracking: A hydrocracking unit processes gas oils over a fixed bed of catalyst in the presence of high pressure hydrogen and produces naphtha, jet fuel and distillate. Overall, the process is relatively flexible in terms of ability to shift yields of product from naphtha, to jet fuel to distillate. Product streams generally have low impurity levels but the overall process is one of the more expensive processes, in terms of capital and operating costs.

Coking: This unit cracks the molecules of the heaviest petroleum fractions (vacuum tower bottoms) into smaller molecules – light olefins, distillate, coker gas oils and coker naphtha. As with the FCC unit, the olefins can be processed in the alkylation or polymerization unit, the naphtha is sent to gasoline blending, the distillate is sent to diesel processing, and the gas oil is processed in the FCC or hydrocracking unit. Many of the output streams are often further hydrotreated to remove sulfur and impurities before being processed in another unit.

Asphalt Processing: This unit processes vacuum tower bottoms into asphalt cement. This heavy tar material is mixed with aggregate (crushed rock) to produce the product known asphalt used in road building and repair.

Hydrotreating: Hydrotreating of the naphtha, distillate, and gas oil streams removes sulfur and other impurities and helps to improve the quality of the finished product in many instances. This unit is required in almost all cases to meet sulfur content maximum specification in gasoline and diesel.

Naphtha reforming: Heavy naphtha from the crude tower and other units is generally low in octane. To improve and raise the octane number of this refining stream, a refinery typically treats the heavy naphtha in a catalytic reformer. Reforming increases the octane. Prior to entering the reformer, a naphtha hydrotreater is generally required to remove impurities (sulfur, olefins, metals). The naphtha reforming product, generally called "reformate," is used as a component in gasoline blending.

Alkylation: This unit reacts unsaturated C3, C4, C5 olefins with isobutane to produce high octane, low RVP alkylate which is a gasoline blending component. The olefins are generally generated from the FCC and coking units. The isobutane is sourced from the atmospheric crude tower and is produced in a C4 isomerization unit. Alkylation units generally have two to three times the yield per unit of olefin feed compared to a polymerization unit.

Isomerization: This unit can be used to convert normal paraffins of naphtha into their isomers having higher octane levels and lower RVP levels (isomerate). Depending on whether the product is recycled through the unit or not, the octane level of light straight run (LSR) naphtha can be increased from 70 RON (Research Octane Number) to the low 80s (no recycle) and 87-93 range (with recycle). The blending RVP value for LSR gasoline isomerized through a one-pass process is 13.5 PSI. The resulting isomerate is used as a component in gasoline blending.

Polymerization: This unit reacts unsaturated C3, C4, C5 olefins over a phosphoric acid catalyst and produces a heavy, higher octane, low RVP naphtha stream (referred to as cat poly gasoline) which is used as a component in gasoline blending.

Depentanization: This unit may be a stand-alone unit or part of individual processing units that produce naphtha. In general, the purpose of the unit to separate C5 high RVP components from naphtha streams in order to lower the naphtha stream's Reid Vapor Pressure (RVP). The existence of depentanization units in a refinery is generally not listed in published lists of refinery process units. This unit is also referred to as C5/C6 removal.

Gasoline Blending: This process blends the various gasoline component blending streams (output from FCC, coker, reformer, alkylate, cat poly gasoline, and light straight run) plus other streams (butane, natural gasoline) to produce finished grade gasolines. In gasoline blending, the process is optimized to blend the correct volumes of component stocks in order to arrive at gasoline product that has the correct final specification with respect to octane, Reid Vapor Pressure, sulfur, boiling range, and aromatics.